Recognizing Relationality through Kombucha Fermentation Practices

Aybars Senyildiz

Master's Thesis

Aalto University

Recognizing Relationality through Kombucha Fermentation Practices

Aybars Senyildiz

Master's Thesis

Aalto University

Master's Programme in Creative Sustainability (CS Design)

Aalto University School of Arts, Design and Architecture (ARTS)

May 2021

Supervisor: Eeva Berglund

Advisor: Emilija Veselova

Abstract

Design for sustainability aims to improve conditions within social, ecological, and technical domains by reconsidering how these domains relate to each other. However, the disciplinary conventions of design lack a practical framework for studying entangled relations between humans and nonhuman entities. For addressing this gap, the thesis explores the concept of relationality that emphasizes the interconnected wellbeing of human and nonhuman entities through kombucha fermentation practices. Due to touted health benefits of fermented kombucha tea, the practice of brewing kombucha has been shared among people and becoming more popular in recent decades. Within the thesis framework, the symbiotic relations among microbial and human bodies during kombucha fermentation served as a stage for recognizing the interconnectedness of human and non-human wellbeing. Interviews with kombucha brewers, a remote collective fermentation workshop, and a design probing activity provided insights into the relations between humans and microbes in the fermentation practices. The concept of relationality and the acquired insights about kombucha fermentation practices informed alternative ways of relating to nonhuman beings. Recognizing relationality opened a reflexive space for reconsidering everyday activities and understanding the 'interconnectedness between humans and others.' The sensory experience and embodied knowledge informed the emergence of relational ethics within human-microbe relations in kombucha fermentation practices. The learnings on human-nonhuman relationality aimed to enrich the discussions in design for sustainability by providing concepts and intuitive tools for exploring social-ecological entanglements.

Keywords: relationality, kombucha fermentation, embodied knowledge, sensorial experience, nonhumans, design for sustainability

Acknowledgements

Proposing the topic of kombucha fermentation for a design thesis would have not been possible without the Creative Sustainability master's program. The kombucha fermentation practice is hardly a subject of design research since it is not a design activity or an artifact within disciplinary conventions. However, within the framework of my thesis, I approached it as a stage for recognizing an alternative way of relating to nonhumans. Therefore, what is designed in my research becomes the exploration of an alternative relation design for recognition.

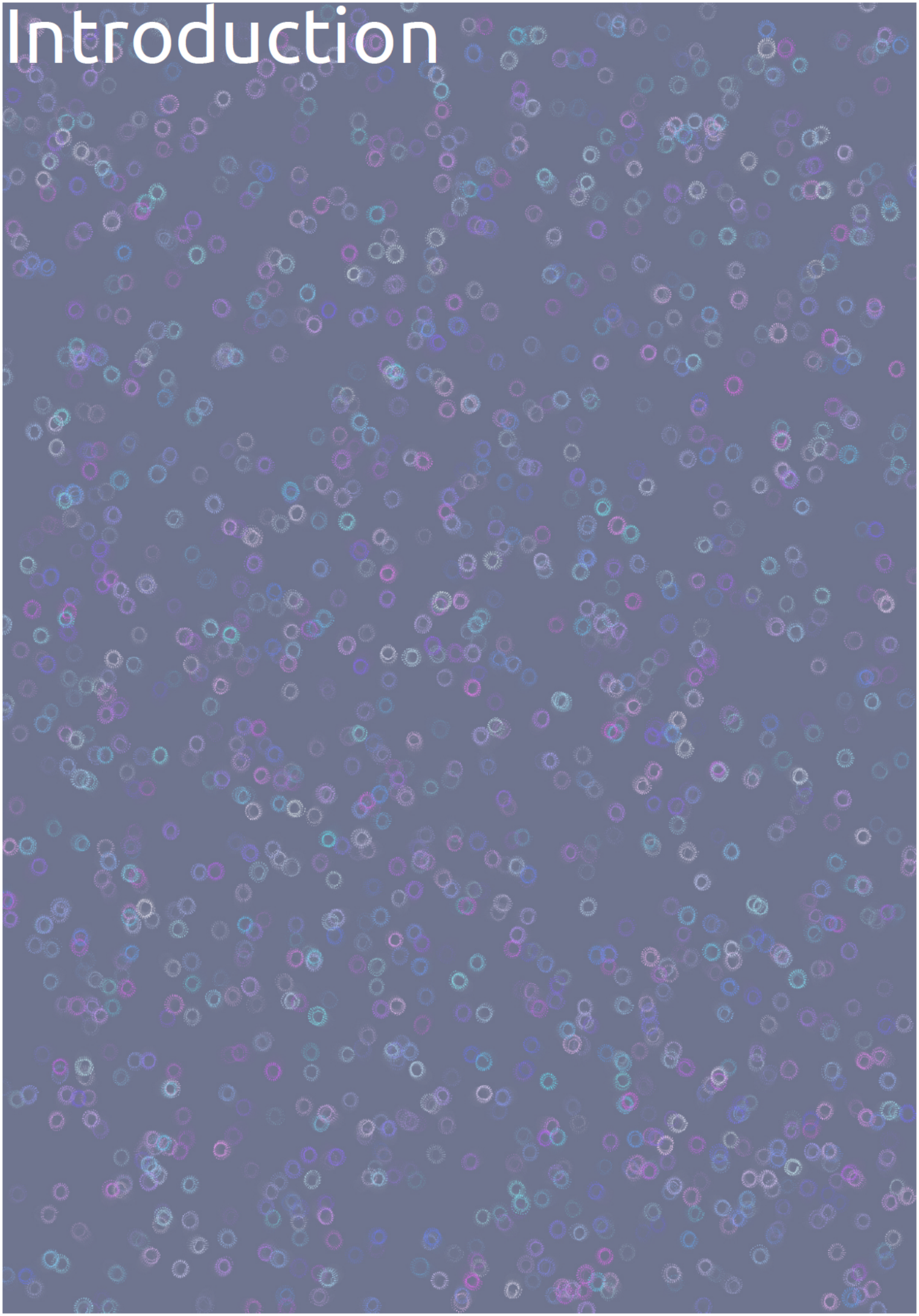
Through the empirical research, my relations with others had the agency to define the content and approach of my thesis. An inch of kombucha SCOBY, I provided from a food workshop three years ago, still lives with me and with the participants of the empirical research. My experience of kombucha fermentation practice enabled me to reflect on the topic of human-nonhuman relations. Moreover, my relations with my thesis advisor, Emilija Veselova, encouraged and guided me through the process with detailed feedback. My relations with the thesis supervisor, Eeva Berglund, opened up a space for creativity but kept the research relevant for design for sustainability. As my partner, Rabia Gülbike Kaya, shared the kombucha SCOBY with our friends and relatives, she made it possible to learn from others.

Furthermore, the experiences from my past and theories from my background enabled exploring the research questions from different lenses. My digital diaries, the literature readings, and the mindmaps also had agency. Therefore, I felt the need to thank for every relation that made this thesis possible.

Contents

List of Figures

Introduction



1. Introduction

As a designer who has studied sustainability, I have primarily relied on concepts to develop my knowledge, emotions, and opinions during my master's studies. Typically, my learnings on sustainability problems and solutions for transformative change relied on abstract concepts that distribute meanings within the social-ecological realm. However, my experiences with microbial bodies informed an experience beyond the constructed concepts that guided me throughout my studies. As microbial relations involved an alternative way of relating to nonhumans, I wanted to explore kombucha fermentation practices in the context of design for sustainability.

Departing from my experience of kombucha fermentation, I explored the relation of sustainment involving human and nonhuman bodies. The symbiotic relations among microbial and human bodies during kombucha fermentation represented a stage for recognizing interconnectedness. During kombucha fermentation practices, recognition emerges from the senses and embodied ways of knowing and opens up possibilities of attuning to microbial bodies beyond human concepts. Since kombucha fermentation involves a rationale that is distinct from the values and systems that reproduce the unsustainable ways of living, the alternative ways of relating to others in kombucha fermentation enabled me to reflect on design for sustainability.

1.1. Background

Human cultures rely on concepts when reproducing social relations and practices. The concepts are constructed to act for the convenience of communication, and they gain meaning through relationships with other concepts and within relationships between individuals, societies, and contexts. However, when concepts get solidified, they create what Whitehead calls the "fallacy of misplaced concreteness," which "fosters dogmatism, limits creativity, and alienates researchers from reality" (as cited in West et al., 2020, p. 308). Within this background, I approached the human-nonhuman divide as a solidified concept. Since the solidified separation of humans from nonhumans justifies the domination of nonhuman beings and the environment, it has been causing unsustainability by justifying the exploitation of nature (Speed, 2006). As a result, the segregation of entangled relationships has made these relationships unsustainable. As Felix Guattari (2000) states, not only is the environment deteriorating, but so are our relations with it (p. 27).

In order to address the unsustainable relationships within the social-ecological realm, it is a crucial challenge to acknowledge the dynamic, blurry, and entangled nature of conceptually divided bodies. For this, in sustainability research, the relations among social and ecological domains are rendered as dynamic, interconnected, and interdependent (Mancilla García et al., 2020; West et al., 2020). With this background, I focused on the relationships within kombucha fermentation practices. Kombucha fermentation practices provided a rich study area where human and microbial bodies are entangled in a symbiotic way. Therefore, kombucha fermentation practices became a stage for the normative aim of blurring the boundaries of the human.

The inquiry of blurring the boundaries of the human is supported by the theoretical learnings from relational approaches that posit relations as prior to entities within systems (Walsh et al., 2020, p. 76). While relational approaches provided the theoretical background of the thesis,

kombucha fermentation practices enabled unfolding the theories on the everyday level. Given that these relations constitute the social-ecological vitality, the theoretical background of my thesis involved a specific inquiry into conceptualizing alternative ways of relating to nonhuman bodies. Although the problem background of my thesis was conceptual, I explored it through a vital and tangible practice of kombucha fermentation. During my research, I held the normative aim of blurring the boundaries around 'human' and emphasizing the interconnectedness well-being of human and nonhuman entities.

1.1.1. Personal Relevance

It has been three years since I started producing my drink in collaboration with kombucha microbes. Thanks to an inch of a *symbiotic colony of bacteria and yeast* (SCOBY) that I supplied from a food workshop during the Istanbul Design Biennale 2018, my partner and I shared our SCOBY with over five people. Most of them shared their SCOBY children with other persons. As the kombucha microbes were replicating themselves, they encouraged us to share their colonies. Furthermore, I engaged with other fermentation activities, such as fermenting yogurt, beer, kefir, and sauerkraut. However, kombucha fermentation has been the most resilient, forgiving, and exciting practice for me. The resilience of kombucha practice could be due to kombucha showing the lively activity of fermentation in the most visible way by forming a layer that makes the microbial activity detectable by the human senses.

Kombucha fermentation is an example of multispecies activity and interaction of sustainment in which human and nonhuman entities develop a rhythm for sustaining the symbiotic relation. While microbial relations required me to immerse myself into another level of reality of microcosmos, the object of study enabled me to view design and sustainability from outside. Exploring kombucha fermentation practices beyond industrial logic and looking outwardly at normality helped me reflect on industrial logic's pervasiveness embedded in contemporary culture and, therefore, in design and sustainability.

1.1.2. Reframing Design for Sustainability

As an industrial designer studying sustainability, I had the privilege to reflect on disciplinary conventions of knowledge and sense-making. The first thing I noticed was the lack of vitality in design and sustainability. I found disciplinary knowledge limited when exploring multispecies entanglement on the everyday level. For example, the design discipline did not grant agency to nonhumans while taking *natural resources* for granted. Neither did sustainability provide concepts to explore everyday practices (Kennedy et al., 2015, p. 2). These could relate to technocentric and top-down approaches that dismiss human-non-human interconnectivity and place the development of solutions solely in laboratories and industrial networks instead of livelihoods and daily life.

Moreover, the dependencies on distribution networks became more apparent despite studying a place-bound production. Although kombucha fermentation is carried out in domestic areas, it needs sugar, tea, energy, and water from the industrial infrastructures. Furthermore, exploring an activity in which producers and consumers are entangled has been challenging within the dominant logic of industrial capitalism in sustainability and design. That logic relies on the externalization of costs and growing

profits through value extraction from land and people (Harvey, 2006, as cited in Feola, 2020, p. 242). Furthermore, labor exploitation and environmental destruction support each other in the global economy, which intensifies the pressure on ecologies (White et al., 2016, p. 96). As Mariana Pestana (2021) verifies, design has already configured relations among people and land on purpose or unwittingly (İstanbul Kültür Sanat Vakfı, 2021). However, the limitations of design and sustainability within industrial logic pointed out that eliminating, dismissing, or obscuring discrete relations are inherent to the disciplinary conventions. Therefore, the identified limitations of design, sustainability, and industrial logic required attentiveness to relations that constitute the mindsets that caused unsustainable practices.

I believe that the limitations of design and sustainability reside in the historical development of these disciplines. Since neither design nor sustainability approaches exist in a vacuum, they have interacted with the values and mindsets of the hegemonic structures such as the culture of modernity (Ehrenfeld, 2008; West et al., 2020; Mancilla García et al., 2020), capitalistic value extraction (Wilson & Bhamra, 2020; Feola, 2020), and neoliberalism (Julier, 2013; Forlano, 2017). Because "[b]lindness to capitalism also risks a return to an idealised image of the capitalist economy" (Feola, 2020, p. 242), I had the motivation of reflecting on the disciplinary conventions in the context of industrial capitalism. However, strong theories tend to grant ultimate power to hegemonic structures and cause powerlessness and limited politics in research and action (Gibson-Graham, 2008). Therefore, it should be noted that design and sustainability might have agency in "creativity to generate actual possibilities" (Gibson-Graham, 2008).

To generate possibilities for sustainability, design for sustainability has started focusing on broader systemic problems rather than limiting design within the material and product level interventions (Ceschin & Gaziulusoy, 2019). For design, this shift meant the "dematerialization of design"(Frascara, 2003). However, I believe that "dematerialization of design" necessitates a critical inquiry into "the value systems within it operates" (Frascara, 2003) and the conceptual language design utilizes (Fry, 2010). For example, Ehrenfeld (2008) proposes a focus on "flourishing livelihoods" rather than solely operating on problem-solution rationale. Moreover, sustainability transition needs to be supported by "everyday-life actions" (Manzini, 2019). Overall, conceptual and critical interplays are needed to reassess the limitations and opportunities of design for sustainability.

Despite the tendencies of externalizing social-ecological relations in industrial supply chains, social-ecological entanglements inform that human well-being is dependent on the well-being of other species and the ecological processes (Rupprecht et al., 2020). Therefore, focusing on interdependent relationships among humans and nonhumans becomes a key study area in sustainability research. I believe emphasizing that human well-being is dependent on nonhumans necessitates ethical and political inquiries into sustainability and design. Manzini (2015) accentuates the vital role of producing sense, in which the ways of seeing and doing can construct meanings for sustainability. Therefore, meanings and values at the everyday level come into prominence for recognizing alternative ways of relating to nonhumans. Consequently, constructing new tools and concepts for ethics and politics that are grounded on everyday life could be possible for design for sustainability.

1.2. Focus and Scope

My inquiry into kombucha fermentation practices strived to blur the boundaries around humans and emphasize the interconnectedness of human and nonhuman entities. These aims required ethical, political, and ontological considerations. Thus, the problem definition of my thesis was conceptual, but I studied the vital practice of kombucha fermentation by getting inspiration from my personal experience and empirical research. For reflection on theoretical learnings, I approached kombucha fermentation as a stage to reflect on the complexities of social-ecological entanglements without limiting my learnings to direct interactions in the physical realm. I combined my observations and learnings from empirical research with the theoretical background emerging from the literature search and my previous studies in sustainability.

Despite being a novel researcher in sustainability, I did not choose to confine myself to sustainability theories. Intending to have a critical perspective, my inquiry into the daily production of life involved flights to different types of knowledge. Therefore, I explored connections between various kinds of knowledge emerging from microbiology, philosophy, humanities, social sciences, critical theories of Marxism and feminism, and knowledge positioned beyond disciplines. As "[p]roper life flourishes in relation to what is not itself" (Colebrook, 2019, p. 176), I expected to enrich the discussions in design for sustainability with inspirations from other areas of knowledge.

1.3. Thesis Structure

Section 2 introduces the methodology of the thesis by presenting the research objectives, the research approach, and research methods. In Section 3, I exhibit my learnings from the literature on relationality and situate relational theories in sustainability research. Section 4 explains the kombucha fermentation practices by providing learnings from recent research in microbiology and multispecies relations in fermentation practices. In Section 5, I present the empirical learnings from interviews and collective kombucha fermentation activity. Section 6 includes the findings from theoretical and practical learnings on kombucha fermentation practices and relational approaches. In Section 7, I combine my learnings from the research and relate them to disciplinary discussions. Finally, Section 8 includes the final remarks that might inform further research.

Methodology

In this section, I introduce the methodology for exploring kombucha fermentation practices through relational approaches. First, I will introduce the research questions and objectives. Second, I will outline the research design for integrating theoretical research with empirical learnings. Third, I will list the methods used for exploring kombucha fermentation practices and relationality. Finally, I will explain the limitations of the research followed by the structure of the thesis.

2. Methodology

My background in critical theories and design practice in the industrial setting informed how design and sustainability manifest the values of prevailing systems that influence all domains of knowledge. However, kombucha fermentation practices inspired me with an alternative way of relating to nonhumans beyond conceptual boundaries between humans and others; embodied, relational, and resilient. Therefore, departing from my personal experiences of kombucha fermentation, I wanted to explore how kombucha fermentation practices can enable recognizing relationality with microorganisms. Furthermore, I was interested in the relational approaches because they provided theories for emphasizing the interconnectedness in the social-ecological realm by different overarching domains of knowledge. However, human concepts did not suffice to recognize relationality with nonhumans. Therefore, I maintained an explorative research approach beyond the established conceptual frameworks of design and sustainability. Since "methods don't just describe but also help to create them" (Halse & Boffi, 2014, p. 19), I held the normative aim of enabling the recognition of the feeling of interconnectedness with nonhuman microorganisms.

My research themes implied a qualitative research approach to develop an understanding of topics, capturing and constructing meanings (Muratovski, 2015), connecting themes, providing insights, and reflecting on learnings. The qualitative research aims to build deep learnings about the experiences of individuals (Muratovski, 2015). I explored the meaning-making processes of people's experiences (Leavy, 2017, p. 9) and reinterpreted them to reframe kombucha fermentation practice as a multispecies activity. I intended to construct a rich picture of the complex connections (Muratovski, 2015, Ch. 4) between relational approaches and everyday life in the context of microbial relations. Therefore, the thesis holds an exploratory approach that aims "to satisfy curiosity, provide better understanding", and provide learnings on a phenomenon (Hart, 1998, p. 47).

2.1. Research Questions and Objective

This thesis intended to make a difference by "suggesting new ways of thinking" and "paving the way for further research in the field" (Muratovski, 2015). In terms of my thesis topic, I aimed to explore an alternative way of relating nonhumans. Thus, I connected the main themes of 'relationality' and 'kombucha fermentation practices' to provide learnings to inform design for sustainability. My inquiry held the normative goal of blurring the boundaries of humans and emphasizing the interconnected wellbeing of human and nonhuman entities. This inquiry implied recognizing relationality with microbes in the kombucha fermentation practices. The research discusses the following questions:

1. How can kombucha fermentation practices open up space for recognizing relationality with nonhumans?

2. In which ways human-nonhuman entanglement steers kombucha fermentation practices?

3. What kind of ethics sustain human-nonhuman relations within kombucha fermentation practices?

4. In which ways can relational approaches ground values within relations in the context of design for sustainability?

2.2. Research Design and Approach

The thesis addresses experience-related learnings about kombucha fermentation practices and theoretical learnings about the concept of relationality. For this, I collected various insights to study the themes from many angles for the qualitative research (Muratovski, 2015, Ch. 4). The bricolage approach enabled insightful opportunities for sense-making (Kara 2015) and flights among disciplines. For Markham, the bricolage approach engages with everyday practices of sense-making (Markham, 2013, p. 65). Moreover, bricolage resonates with relational approaches because "bricoleurs act on the concept that theory is not an explanation of nature - it is more an explanation of our relation to nature" (Kincheloe, 2005, as cited in Markham, 2017). With this background, I intended to provide learnings from various types of knowledge, including philosophy, social sciences, humanities, microbiology, and non-disciplinary knowledge. Non-disciplinary knowledge stemmed from empirical learnings and personal experiences with kombucha fermentation.

The explorative approach involved being attentive to the concepts and tools used in research. As established concepts and tools might carry the agency of their context and limited objectives, I needed to distance my methods from traditional design research methods like the user-centered design or participatory design. Cutting the relations with prevailing methods and frameworks in design required me to navigate the research process with my intuition and creativity. The intuitive approach and the content of the thesis supported each other since empirical research involved attuning to nonhumans beyond human concepts, as well as my research process involved attuning to content beyond disciplined concepts. Therefore, being creative in research can also enable new learnings (Hart, 1998, p. 22), and creativity in research requires intuition, imagination, and wonder (Kara, 2015). Therefore, I adapted design methods and research methods according to emerging necessities of research questions and emerging themes. Design research informed the messiness of design research methods, but the mess should be empirically situated and critically investigated in the research (Halse & Boffi, 2014, pp. 26-27). For this, I kept learning diaries and used mindmaps for recording my learnings and recording the critical decisions during my thesis process. The records on learnings and decisions enabled me to ground my decisions through the process by reflecting on them.

2.3. Methods

The research topic required incorporating theoretical and empirical research methods. The first part of the literature review explored the topic of relationality in the context of sustainability. The second part explored kombucha fermentation practices in the context of everyday life, and personal communication with a lecturer guided me to interpret the social side of microorganism research and fermentation practices. The empirical research consisted of two activities. The interviews explored how kombucha brewers interacted with microbes in kombucha fermentation practices. Furthermore, I facilitated the collective kombucha fermentation activity remotely. The collective kombucha fermentation activity aimed to reflect on human-nonhuman interactions with the help of a recipe writing activity and a collective reflection workshop.

2.3.1. Literature Review

The literature review "summarizes, interprets and evaluates existing literature" (Collins,

2017). The literature review included the evaluation of documents in various formats. I explored journal articles, books, recipe books, and podcasts to access diverse knowledge and reflections about research topics. The connections between different ideas enabled understanding the research phenomena (Hart, 1998, p. 1). I have carried out the literature search in two different categories. First, a methodical search (Phelps et al., 2007) on relationality provided literature for establishing the theoretical basis. Second, a literature search on kombucha fermentation practices involved a methodical search and various sources to provide insights about the nature of the fermentation practices and the recent microbiology research. The methodical search procedure for literature searches included brainstorming key terms and synonyms for creating search syntax, selecting the databases to be searched, methodical searching, taking notes on insights about search results, and limiting searches (Phelps et al., 2007). After listing the acquired literature, I used several filters and prioritization methods to focus on the literature relevant to the research problem.

Literature search on relationality utilized the terms: '*relationality,' 'interconnectedness,' 'ecological relationality,' 'imagining relationality,' 'and 'sustainability.*' The keywords and their combinations created the search syntaxes listed in Appendix A. Moreover, literature searches enabled creating bibliographic network visualizations based on search results and the research results' references. I used the bibliographic visualizations to develop general insights into the literature, influential authors, and dominant disciplines. The insights from bibliographic visualizations enabled understanding the status of the literature, influencing authors, foundational publications on the topic, related disciplines, and approaches.

Literature search on kombucha fermentation utilized the terms *'kombucha', 'fermentation,' 'microorganisms,' 'sustainability,' 'ecology,' and 'review.'* The keywords and their combinations created the search syntaxes listed in Appendix B. Since scientific sources dominate academic search tools, the interest in exploring the social and cultural meanings around kombucha fermentation required incorporating alternative search strategies. I used online search engines for generic purposes and personal knowledge to enrich the literature on kombucha fermentation practices. For example, I reviewed a podcast series named "Ferment Radio" and several books, including fermentation recipes.

2.3.2. Interviews and Personal Communication

To provide empirical learnings about kombucha fermentation practices, I conducted interviews and designed a collective fermentation activity for the research. The empirical research was informed by learnings from the literature searches. The literature on relationality enabled me to determine the theoretical themes to be explored, and the literature on kombucha fermentation provided initial insights into human-microbe relations. As Figure 1 shows, I referred to the themes from the literature search, my learning diaries, and personal experiences to identify interview themes and guiding questions. Furthermore, my personal experience on kombucha fermentation guided me throughout the research process.

The interviews examined the kombucha fermentation practices and the human-microbe relationship during fermentation. Semi-structured interviews were conducted remotely with four participants. I asked three participants to reflect on their journey of fermentation and the interaction between

Figure 1. The process of creating interview questions

the human and nonhumans within the fermentation practices. I conducted the interviews in an explorative manner and kept the order and composition of questions open. I conducted the interviews in Turkish, which is the native language of the participants and myself. The interviews started with general conversations about the participants' fermentation journey and then focused on predefined themes about kombucha fermentation practices.

An online consent form provided participants with information on the extent of the interviews and the use of personal information. As a matter of confidentiality, I will not reveal the names of the participants in my thesis. I replaced participants' names with the numbers starting with the letter 'P,' which stands for 'participant.' I used audio recordings to transcribe the interviews afterward. I created the interview notes immediately after the interviews to recall the ideas when they are fresh. I will present these insights in section 5.1.3.

Moreover, I held a personal communication with a lecturer who guided me about the social meanings related to microbiology research. For this, I reached out to Salla Sariola, a lecturer at the University of Helsinki, studying and teaching microbes in the context of sociology, ethics, feminist technoscience, antibiotic resistance, and global healthcare. Moreover, Salla Sariola is a fermentation enthusiast who was part of the Kilpisjärvi Collective (2021).

2.3.3. Collective Kombucha Fermentation Activity

Collective Fermentation Activity included a two-week-long collective fermentation process. We conducted the activity remotely and simultaneously. Five participants (including the researcher) started the kombucha fermentation simultaneously. The participants wrote recipe notes to reflect on microbial interaction. The notes included reflections on senses, thoughts, and emotions. The prepared recipe is used as a design probe to generate knowledge about the dynamics of human-microbial relationships and the distributed agency within fermentation. The activity concluded with a closing activity that enabled participants to delve into the microbial interaction within the fermentation process. The designed activity included the following elements.

- A kick-off meeting to introduce the activity to participants,

- An online group chat for enabling communication among participants,

- A design probe activity of writing a recipe with notes on observations, thoughts, and emotions

- A collective reflection workshop as a closing activity.

The ***kick-off meeting*** included a short presentation about the scope and the timeline of the activity. In the kick-off meeting, I introduced the design probe activity and guided participants to write their fermentation recipes during the kombucha fermentation process. After the kick-off meeting, I created a group chat to communicate the activity and enable participants to talk about fermentation in general.

Participants shared information about kombucha fermentation and their recipes in an ***online group chat***; thus, other participants had the opportunity to check the recipes. The group discussion also included spontaneous ideations about trying new recipes with kombucha, such as trying the second fermentation for extra carbonation. I also used the group chat to enable the participants to adapt to talking about kombucha together.

The primary medium for communicating the kombucha fermentation practice involved ***written personal recipes by participants***. The creation of recipes enabled participants to think and feel the interaction with microbes at a discursive level and refer to self-observation during kombucha fermentation. Furthermore, participants could capture the moments of interaction with notes to reflect on them collectively later.

The ***collective reflection workshop*** involved a reflection session on the fermentation practices based on the recipe notes participants wrote during the Collective Kombucha Fermentation Activity. The collective reflection workshop was based on the interpretation of embodied ways of knowing and sensory experiences. For this, recipe notes of participants were compiled into an online board (see Appendix J) and presented during the reflection workshop. In this way, participants could recall their memories of kombucha fermentation through their own experienced stories.

The need for reflection on human-microbe stemmed from a normative aim of recognizing the interconnectedness and the agency of microbes in fermentation practices. I did not explicitly mention the normative goal until the reflection workshop but the goal guided the design of the activity. This understanding stemmed from an inquiry into the ways fermentation actions were shaped by the needs and wellbeing of the kombucha SCOBY. Through the collective kombucha fermentation activity, the main objective was to recognize how participants attuned themselves to the needs of microbes.

2.3.4. Integration of Findings

In Section 6, I aimed to provide fresh insights about the meanings (Saldana et al., 2011, p. 89), concepts, and experiences related to human-nonhuman entanglements within kombucha fermentation practices. While I was collecting learnings from the empirical research, I took memoing notes (Saldana et al., 2011, p. 90) to reflect on them through the research process. The reflections during research phases also involved analyzing accumulated learnings (Muratovski, 2015, Ch. 4.6). When empirical research and literature searches ended, I categorized learnings from empirical and theoretical research into themes (Saldana et al., 2011, p. 108). I analyzed these themes by finding interrelationships (Saldana et al., 2011, p. 92) among them. Finally, I presented the

compiled insights in four themes guided by research questions.

2.4. Research Ethics

Ethical research aims to protect participants from possible risks about the research process, data collection, and storage (Muratovski, 2015, ch. 3.9). I informed the participants with online consent forms when involving them in the empirical research process. During interviews and group meetings, I introduced how I would collect data and use them in my research. Participants who fermented kombucha during the research had at least three months of fermentation experience. Therefore, experienced participants were able to detect problems in their fermented kombucha beverages. One of the participants had a spoiled SCOBY during the research. The participant discarded the spoiled SCOBY due to the risk of contamination. The empirical research did not involve any other perceived risks. Another consideration about research ethics was the role of the researcher.

Since the participants for the empirical research were from my social sphere, the line between researcher and participants was blurry. Rather than using strict interview language and procedures, I tried to have everyday-level discussions with participants. Moreover, I tried to blur the researcher-participant divide with my language use and interview style. On purpose, I avoided having a strict interview procedure to allow for lively discussions. Moreover, I have adapted my terminology according to the participant's terms by avoiding terms and definitions acquired during the literature search. For a profound interaction, I also tried to include everyday conversations and unobtrusively mention my experiences. With this approach, I tried to distance myself from a position that aims to extract learnings from participants. Within the empirical research, I tried to adopt an approach to learn together with the participants. These involved not directing prepared questions in an interview but building on a conversation together.

2.5. Remote Research

Due to Covid-19 precautions during the research timeline, I designed and conducted my research in a remote mode of communication. For my research, I asked participants to have video calls by using mobile phones or computers. The remote research enabled me to include participants from my home country Turkey. Therefore, I was able to conduct my empirical research in my native language. Furthermore, I believe that the remote mode of research opened a space for participants. With low exposure to one-to-one interaction, the participants found more time to reflect on the experience of fermenting kombucha. Despite the remote interaction, I provided learnings about embodied and sensory aspects of participants' kombucha fermentation practices thanks to my previous experience of fermenting kombucha. During the empirical research, participants were living in their homes where they also brew kombucha.

Relationality

This section presents relational approaches for the study of non-humans in the context of sustainable research. First, I will describe the concept of relationality by drawing on humanities and social sciences. Second, I will describe how relational approaches emphasize the agency of relations and emphasize the interconnectedness for blurring the conceptual categorizations within social-ecological entanglements. Third, I will explore relational approaches which ground the knowledge within relations by acknowledging situatedness and diverse ways of knowing. Fourth, I will explain relational ethics and how relational values can contribute to environmental studies. Then, I will position the concept of relationality within everyday life.

3. Relationality

Sustainability aims to reconfigure the complex relations within social-ecological entanglements for normative ends. Sustainability involved systemic approaches based on interactions between social and ecological entities (West et al., 2020, p. 305). However, those interactions "take place among fixed entities" (Emirbayer, 1997, pp. 285-286) which rely on human concepts. West et al. (2020, p. 305) argue that relational approaches challenge the mechanistic approaches defining systems as the sum of interacting entities. On the contrary, relational approaches emphasize the vitality of relationships when exploring social-ecological entanglements. For this, relational approaches acknowledge the agency of relations and interdependencies within the social-ecological entanglements (Mancilla García et al., 2020, p. 4). Therefore, relations are more fundamental than the essences of entities (Walsh et al., 2020, p. 76). Recognizing the agency of relations could make it possible to identify the constitutive role of relations across conceptually separated categories of 'human' and 'nonhuman.' Therefore, recognition of nonhumans could open up space for more fluid theorization and transformative change for sustainability. For this, I delve into relational approaches for studying relationships between humans and nonhumans.

3.1. Defining Relationality

Relational perspectives study relationships to understand "the whole not so much as a system of objects but a network of relationships" (Lejano, 2019, pp. 1-2). Rather than relying on unchanging and fixed beings, relational approaches confirm that encounters and relations generate the dynamic and fluid life (Colebrook, 2019, p. 175). Since relations constitute the fabric of the socio-ecological realm (Colebrook, 2019, p. 175), focusing on relations enables grasping the entangled relationships of social and ecological reality without staying within abstract categorizations (West et al., 2020, p. 308; Blaser & Escobar, 2016). Therefore, relational approaches involve the possibility of conceptualizing the intertwined nature of sustainability issues in a more vital way by moving beyond prevailing categorizations based on the separation of the social from the ecological.

Relationality has been a significant theme in many discourses that focus on conceptualizing entanglements. Those entanglements generally aim to reconfigure conceptual dichotomies predefined by concepts such as nature/culture, mind/matter, human/nonhuman, and object/subject (Walsh et al., 2020, p. 80). Many disciplines have adopted relational approaches for the study of entangled relationships. The literature on relationality has emerged within various disciplines such as "neuroscience, cognitive science, consciousness, psychology, archaeology, philosophy, cosmology, cultural history, social change, politics, organizational behavior, theology, ecology, and feminist spirituality" (Lange, 2018, p. 283). In the context of human and nonhuman relations, new materialism, ecofeminism, deep ecology, political ecology, indigenous wisdom, and posthumanism draw from relational approaches to emphasize human dependence on nonhumans and the environment (Walsh et al., 2020, pp. 76-79; West et al., 2020, p. 308; Hirvilammi & Helne, 2014). West et al. (2020, p. 308) use the term "relational turn" to refer to the interest in relational approaches in humanities and social sciences. "Relational turn" involves ambitions to challenge the legacy of the modernist paradigm. Furthermore, these approaches counter modernist dichotomies and "emphasize the

role of materiality in social and cultural life" (West et al., 2020, p. 308).

Various thinkers from different traditions and discourses have adopted relational approaches within Western knowledge. For example, philosophers like Heidegger, Levinas, and Whitehead incorporated relational approaches in their work (Fry & Tlostanova, 2020). The network visualizations created during the literature search revealed that thinkers like Judith Butler, Gilles Deleuze, Sara Ahmed, Donna Haraway, John Law, Bruno Latour, Tim Ingold, and Pierre Bourdieu have been influential in academic discussion about relationality (see Appendix C). Moreover, during my research, I observed that relational approaches draw from concepts developed by feminist epistemology to explore the relations between power, culture, and materiality, such as "material-semiotic" and "situated knowledge." Moreover, science and technology studies, feminist new materialism, and relational approaches have the shared ambition to re-connect cultural theories to the material realm. Due to dissatisfaction with the linguistic turn in social and cultural theories, new materialism posited 'turn to matter' (Sanzo, 2018). However, the 'turn to matter' did not envision a solid material world but a world of ever-changing entities and reciprocal relations among matter, space, and time (Barad, 2007, p. 198). The dynamism in relational approaches might enable non-essentializing solidified concepts in social domains. For example, relational approaches share the same insights as Butler's arguments for developing a non-essentializing approach to gender (Sanzo, 2018).

In many traditional worldviews, relations are conceived of as an inherent feature of the world (Pedersen, 2014, p. 202). For example, relational approaches are common in North American Indigenous philosophies, Southern African Ubuntu, Andean Pachamama, SumakKawsay, Indian correlation principle so-hum, and Eastern mysticism (Lange, 2018, p. 283; Fry & Tlostanova, 2020). For example, 'Chinese correlative thinking' informs a cosmos in which everything flows and the elements are considered a 'species of imagination' due to the perspective of the correlator (Fry & Tlostanova, 2020, Ch. 1). These approaches inform rethinking the conceptual divides that solidify the categorizations of humans and nonhumans in the context of sustainability. However, Walsh et al. (2020, p. 80) observe that relationality has been marginalized within sustainability. I believe that this could be related to the scientific foundations of sustainability retreating from traditional knowledge frameworks involving relational approaches.

The literature search revealed five articles that recently overviewed relationality as their central topics to provide learnings for sustainability (see Mancilla García et al., 2020; West et al., 2020, Walsh et al., 2020; Lejano, 2019; Helne & Hirvilammi, 2015). As Walsh et al. (2020) envisioned a transition "[t]owards a relational paradigm in sustainability research, practice, and education," West et al. (2020) explored the implications of "[a] relational turn for sustainability science." Moreover, Mancilla García et al. (2020) explored concepts for "[a]dopting process-relational perspectives to tackle the challenges of social-ecological systems research." The article by West et al. (2020), with the title of "A relational turn for sustainability science?" initiated an interesting discussion in sustainability research (see Raymond et al., 2021; West et al., 2021). Moreover, many studies have examined relational values for environmental ethics (see West et al., 2018; Himes & Muraca, 2018; Stålhammar & Thorén, 2019). Since these articles that discuss relational approaches in sustainability are recent studies, I comment

that relational approaches are just being introduced to sustainability research.

3.2. The Agency of Relations

As relational approaches prioritize relations over essences, they assert that ***relations constitute entities*** (Mancilla García et al., 2020, p. 4; Barad, 2007, p. 10). For example, White et al. (2016, p. 34) interpret Haraway by stating that human is "relationally constituted by culture, history and many other life forms." Therefore human is "leaky and porous" rather than having predefined boundaries (White et al., 2016, p. 34). Briefly, things and subjects become themselves through relations (Emirbayer, 1997, p. 287). Therefore, the state of 'becoming' counters the state of 'being' in relational approaches. Entities in systems have dynamic processes of becoming rather than having "reified substances" (Emirbayer, 1997, p. 285). To describe the state of becoming, West et al. (2020, p. 310) refer to Debaise and DeLanda by arguing that entities can be "understood as 'events': temporary nodes, stabilizations or patterns of relations, produced within dynamic intersecting processes." The state of becoming in relational approaches ***undermines the substantialist explanations*** that rely on unchanging and isolated essences of entities (West et al., 2021, p. 110; Emirbayer, 1997). The substantialist approaches "are closely entangled with positivist epistemologies, where concepts are understood as abstract mental constructions separate from 'the world itself' (Schaffer, 2016, as cited in West et al., 2021, p. 110)." Although the sciences and human knowledge still grasp the static essences and operate with "reified substances" (Emirbayer, 1997, p. 285), relationality reveals that relations and negotiations are constantly ***reconfiguring concepts*** (West et al., 2021, pp. 111-112).

For example, the feminist practice has undermined the essentialist assumptions about gender in society by pointing out the social construction of the gendered bodies through social relations (Butler, 2001, p. 23).

For emphasizing the agency of relations with nonhumans, relational approaches reject some of the prevailing assumptions in modernist thought. These assumptions involve dichotomies underpinning the ***conceptual borders between humans and nonhumans*** and contributing to human superiority over nature (Hirvilammi & Helne, 2014, p. 2162). However, human superiority leads to unsustainability by instrumentalizing the nonhuman environment as a material source for the needs of humans (Lehtonen et al., 2018, p. 862). On the contrary, challenging human superiority can enable human beings to become 'earthbound' rather than 'earthmasters' (Colebrook, 2019, p. 179). Thus, relational approaches criticize dichotomous thinking based on the human-nature divide in Western thought (White et al., 2016, p. 33). Karen Barad points out that the border of 'human' and 'nonhuman' is "both political and ethical concern," and these borders are not fixed (as cited in Hey, 2019b, p. 154). In order to challenge the borders that produce human-centric worldviews, relationality focuses on the mutual relations and interdependencies between humans and nonhumans (Mancilla García et al., 2020, p .2; Walsh et al., 2020, p.76).

Relational approaches reject substantialist assumptions and dichotomies because these assumptions dismiss the agency of nonhumans and the materiality of the world. Relationality highlights the ***liveliness of matter*** by horizontalizing humans with nonhumans and presenting their efficacy (Bennett, 2010, p. 133). For example, food is "an active inducer-producer of salient, public effects, rather than a passive resource at the

disposal of consumers" (Bennett, 2010, p. 134). The biological and non-biological matter becomes "co-constituting assemblages" (Walsh et al., 2020, p.77). Therefore, nonhumans and the environment are not passive subjects that need to be regulated or protected by humans but lively processes that have a central role in social-ecological entanglements. In this way, relational ontology provides a language to involve "emergent forms of life" into politics without confining to dichotomies (Blaser & Escobar, 2016).

The dichotomous thinking also manifests itself in systems theories guiding sustainability (West et al., 2020, pp. 305-307). Modern dichotomies separate social, ecological, and economic systems (Lehtonen et al., 2018, p. 862) and reduce the interactions between these domains to material exchanges (Lejano, 2019, pp. 6-7). Mancilla García et al. (2020, p.5) point out the ***interdependencies between social and ecological*** are still missing in social-ecological systems research. For example, the dominant narrative of sustainability focuses on carbon dioxide emissions rather than questioning the social construction of capitalist accumulation commodifying the nonhuman environment (Feola, 2020, pp. 242-247). The interconnectedness of social and ecological domains requires a mindset "recognizing that the challenges of climate change are entangled with many other problems such as poverty and globalization" (Mancilla García et al., 2020, p. 5). Similarly, relational approaches aim for a hybrid theory based on the interconnectedness of social and ecological domains that can move beyond dichotomies and human exceptionalism by decentering humans (Walsh et al., 2020, p. 76). For this, ***the feeling of interconnectedness*** can bridge humans with nonhumans (Escobar, 2011, p. 138). Since humans are dependent on the environment (Hirvilammi & Helne, 2014), we are "ecologically embodied and embedded" creatures (Benton, as cited in White et al., 2016, p. 32). Similarly, traditional ecological knowledges that did not separate nature and culture focused on the interdependent aspects of social-ecological entanglements (Walsh et al., 2020, p.77). Moreover, the notion of interconnectedness within social-ecological entanglements has been elevated by multispecies studies within sustainability. For example, Rupprecht et al. (2020, p. 1) notify that "living beings and their wellbeing are interdependent." They propose the development of new frameworks that can involve the wellbeing of all living beings and processes.

According to Colebrook (2019), relationality cannot be "imposed from above but emerges organically" (p. 179). On the contrary, systems perspectives within sustainability research generally conceive change as constituted by external drivers or normative 'interventions' (Mancilla García et al., 2020, p. 4). However, moving beyond interactions between static entities and categories necessitates an understanding of change 'as coming from within' (Santos, 2015 as cited in Mancilla García et al., 2020, p. 4). Therefore, relationality ontology is emergent and animated by agencies (The Kilpisjärvi Collective, 2021, p. 6) rather than external interventions. Similarly, Braidotti (2006) defines relationality as emergent like rhizomatic thinking, a metaphor developed by Deleuze. The metaphor of rhizomes stems from the insight that "it is crucial to invent conceptual schemes that allow us to think the unity and the interdependence of the human, the bodily and its historical 'others' at the very point in time when these others return to dislocate the foundations of the humanistic worldview" (Braidotti, 2006, p. 203). The concepts of ***emergence*** and interdependence decenter humans in systems by considering things as "mutually constituted" (Sharma, 2015, as cited in Escobar, 2018, p. 101).

Since modernism and the existing symbolic system reproduce human-centric conceptual systems for communicating complexity, reflection on concepts can open up space to imagine alternative ways of being and seeing the world (Mancilla García et al., 2020, p. 1). Since conceptual boundaries regulate the disposal of life, it is necessary to reconsider the boundaries of life, matter, nonhumans, and human. Relationality can enable reconsidering these boundaries, which limit recognition of the entangled nature of the socio-ecological realm (Walsh et al., 2020; West et al., 2020). Relational approaches remind the agency of relations and nonhumans within social-ecological entanglements by emphasizing interconnectedness. To illustrate the agency of relations, Colebrook (2019, p. 178) reveals the central role of relations in life by reminding us that the "end of the world" scenarios actually involve the loss of relations that create the social fabric.

3.3. Grounding the Knowledge

Current frameworks of knowledge render knowledge as decontextualized (Lejano, 2019, p. 2). Dichotomous thinking, specialization, studying parts, and reified categories dissect the knowledge about social-ecological entanglements (Lehtonen et al., 2018, p. 862). For example, the integration of social and ecological knowledge is not sufficient yet in sustainability research (Mancilla García et al., 2020, p. 3). Likewise, Guattari (2000, p. 41) pointed out the need to connect the knowledge on "the socius, the psyche and 'nature.'" For Fry and Tlostanova (2020), current problems with epistemological frameworks of creating abstract and ***decontextualized knowledge*** are related to the way of thinking that created contemporary problems. Current neoliberal knowledge production favors fragmented and factual knowledge, which is less relational (Fry & Tlostanova, 2020). Therefore, current solutions can "technically be solved," but "political, economic, cultural delivery of the solution" is not precise (Fry & Tlostanova, 2020).

The limitations of established epistemological frameworks to study social-ecological entanglements stem from the concepts of reason, human superiority, atomism, objectivism, and universalism (Norgaard, 1994; Laininen, 2018, as cited in Lehtonen et al., 2018, p. 861). These concepts can be traced back to ideas of enlightenment supported by "the development of science, technology, and industry throughout the modern period" (Walsh et al., 2020, p. 77). Walsh et al. (2020, p. 77) explain how modern western epistemologies justify human superiority.

> "They [modern western epistemologies] posit: (1) The idea that causation is determined only by external relations between objects; (2) that no object can be understood outside its relation to thought; (3) that primary and secondary (sensible) qualities are separable and that science can objectively study the former without the latter; (4) that nature can be mastered, 'her' secrets revealed to instrumental reason and scientific 'progress'; and finally, (5) that mind and body are separable substances, and that the latter is the domain of objective scientific inquiry (Walsh et al., 2020, p. 77)."

Since the limitations of current epistemologies partially stem from the reified conceptual divisions, relational approaches aim to bridge the fragmented and decontextualized knowledge emerging from different domains (Fry & Tlostanova, 2020). However, connecting knowledge domains require reconsidering the contexts where knowledge is produced and utilized.

Therefore, while connecting knowledge across domains and categories of knowledge, relational approaches aim to situate knowledge within relations.

Feminist discourses, such as standpoint theory and intersectional analysis, offered the concept of ***situated knowledge*** to reveal that "scientific knowledge is fundamentally shaped by social relations and practices" (Walsh et al., 2020, pp. 77-78). Similarly, relational approaches emphasize situatedness and path-dependence of knowledge production (West et al., 2020, p. 312). Situated knowledge reveals that knowledge is constructed relationally (Haraway, 1988; Lehtonen et al., 2018, p. 863), undermining the objectivity claims about knowledge production (Lehtonen et al., 2018, p. 863). In other words, subject and object are not separated in the creation of knowledge because "we know because we are of the world" (Barad, 2007, p. 185). Furthermore, according to Emirbayer's (1997, p. 300) interpretation of semiotics, concepts are situated in relation to the other concepts in the web. Therefore, subjects locate the meanings and knowledge within relational networks. With this background, feminist discourses and relational approaches consider knowledge as 'contingent' and 'situated' within its context (West et al., 2020, p. 318).

Situated knowledge necessitates recognizing the ***diverse ways of knowing*** by moving beyond disciplinary boundaries. Relational approaches address relations across domains for integrating knowledge from disciplinary and non-disciplinary contexts (Mancilla García et al., 2020, p. 5). A relational approach to knowledge would encompass experiences and practices beyond disciplines (West et al., 2020, p. 307), affects beyond knowledge (Hirvilammi & Helne, 2014, p. 2162), intuition beyond reason (Escobar, 2018, p. xv), and a nonhuman realm beyond human realm (Rupprecht et al., 2020, p. 4). Moreover, traditional knowledges provide understandings of relationality (Walsh et al., 2020, p. 80) and acknowledges the agency of nonhuman beings (Rupprecht et al., 2020, p. 3). For Barad, including or excluding things can produce different realities (as cited in Hey, 2019b, p. 151). Therefore, knowledge frameworks have political power. For example, ecofeminists argue that science and technology contributed to the control of nature and women (Walsh et al., 2020, p. 79). Therefore, justice and power are relevant to social-ecological entanglements (Mancilla García et al., 2020, p. 3). Relational knowing should be supplemented with ethical considerations (Lehtonen et al., 2018, p. 864). Nevertheless, relational approaches do not render ethics as separated from embodiment and define ethics as relational.

3.4. Relational Ethics

As relational approaches inform decentering human agency (de la Bellacasa, 2017, p. 143), "a new kinship system" is needed to bridge conceptual domains of human and nonhuman (Braidotti, 2006, p. 202). The interdependence of humans and nonhumans informs the necessity to care for nonhumans (Rupprecht et al., 2020). However, for relationality, "care is not simply an emotional sentiment in the individual human mind, but an embodied, collective and reciprocal practice involving humans and nonhumans" (West et al., 2020, p. 314). Therefore, ***ethics of care*** becomes an emergent practice derived from the embodiment, situatedness, and political stance (West et al., 2020, p. 315). For example, 'ethics of care' in permaculture is based on the recognition of being embedded in relationships that "have consequences for more than ourselves and our kin" (de la Bellacasa, 2017, p. 146). The "kinship" with nonhumans could emerge from having ties with nonhumans beyond the nature-culture

divide (Haraway, 1992, as cited in Braidotti, 2006, p. 199-200). This kind of ethics does not rely on abstract moral norms, but they are ethical doings emerging from corporeal relations with the nonhuman realm (de la Bellacasa, 2017, p. 145). Therefore, relational ethics is grounded on relations, attachment, and embeddedness rather than abstract categorizations and norms. In this way, relational ethics can embed the ethical experience into everyday practices of nonhuman relations and build resilient ethical relations with nonhumans beyond human concepts.

3.4.1. Relational Values

Relational ethics introduces relational values for the context of environmental ethics. As environmental ethics relate to "the normative underpinnings that guide how humans should behave towards nature" (Stålhammar & Thorén, 2019, p. 1203), environmental ethics involved discussions exploring whether the value of nonhumans resides in intrinsic or instrumentalist values (West et al., 2020, p. 316). As intrinsic value relied on valuing nature "for its own sake," and instrumental value focused on the needs of human societies when referring to value propositions (Stålhammar & Thorén, 2019; Himes & Muraca, 2018). While intrinsic values remained weak due to lacking a valuing subject (Stålhammar & Thorén, 2019, p. 1206), instrumental values did not address the exploitative commodification approach treating nature as a resource (Himes & Muraca, 2018, p. 5). Relational values as a third category can be defined as a supplementary category (Himes&Muraca, 2018, p. 5), a connecting category (Stålhammar & Thorén, 2019, p. 1201), or a context-related alternative to existing value categories (Chan et al., 2018, p. 6).

Being emergent, grounded, and context-dependent, relational values can provide opportunities "for transformative change toward sustainability" (Chan et al., 2018, p. 1). According to Chan et al. (2018), relational values are context-related and can be a boundary object concept for the meaningful integration of social sciences and diverse knowledge into sustainability science. Therefore, by connecting social and ecological issues, relational values support intersectional analysis and "contextualize human-nature interactions in light of asymmetrical power relations and dynamics between assemblages or networks of interest" (Walsh et al., 2020, p.80). Moreover, relational values necessitate reconsidering dominating value frameworks that rely on instrumentalizing market mindset and "settler's narrative" (Himes & Muraca, 2018, p. 5) that are based on strategies of commensurability, scalability, and interchangeability (Tsing, 2015, pp. 38-40). According to Tsing (2015, pp. 38-40), these strategies enable the displacement of humans and nonhumans by transforming the social-ecological realm into a plantation for economic activity. As the relational inquiry on knowledge production revealed the need to ground knowledge claims within relations, relational ethics also implies reconfiguring the concepts of ethics in a more grounded way.

3.4.2. The Tension between Relationality and Normativity

I believe that the need for grounding ethics in relation contradicts the normative goals of sustainability. The normative premise of relational approaches in sustainability involves valuing the wellbeing of nonhumans as well as the interdependence between species (Rupprecht et al., 2020, p. 5). However, relational values contradict the provision of values through top-down narratives and managerial approaches. Likewise, Barad (2003, pp. 805-812) and Braithwaite (2002) are concerned about

representationalist tendencies that create abstractions for ***top-down management of ethics***. While these abstractions are based on human concepts, universal values appear to be "out of touch," and traditional ethics is based on abstractions (Culbertson, 2013, p. 451). However, traditional ethics prioritize rules over relations and "dominate human passions by privileging consciousness" (Deleuze, 1988, as cited in Mandalaki & Fotaki, 2020, p. 750). Although this tension uncovers the limitations of contemporary ethical frameworks, de la Bellacasa (2017, p. 127) argues that ethics embedded in relations can provide creative and inspiring outcomes for human-nonhuman relations.

3.5. Relationality in Everyday Life and Performativity

Relational approaches intersect with enacted approaches when addressing the neglect of everyday life in modern scientific knowledge. Ignoring everyday life stems from the substantialist paradigm separating the mind from the material world (West et al., 2020, p. 311). The literature on relationality draws on cognition research to emphasize enacted approaches that inform brain-body and environment interactions (Walsh et al., 2020, p. 78). These approaches are related to affect, emotion, and body politics (Walsh et al., 2020, p. 78). For Barad (2007), "[s]pace, time, and matter are mutually constituted through the dynamics of iterative intra-activity" (p. 198). Therefore mind extends to "dynamic inter-actions between coupled brain-body-environment systems" (Varela et al., 1991; Clark, 2008, as cited in Walsh et al., 2020, p. 78). Furthermore, the agency is shared with the languages and concepts to "navigate the world" (Cook & Wagenaar, 2012, as cited in West et al., 2020, p. 314), and "language does not simply reflect the world but actively intervenes in and shapes it" (Butler, 1988, as cited in West et al., 2020, p. 314). With this background, relational approaches envision reconfiguration of concepts for embracing the complexities (West et al., 2020, p. 318).

Although relational approaches reveal the agency of relations and the pivotal role of embodiment, humans "have been separated from the social production of reality, the common ecological, social, material and nonmaterial reality" (Lehtonen et al.., 2018, p. 862). Within the context of sustainability, disconnection from the production of reality could mean a lack of 'capabilities' transforming the livelihoods for humans. In environmental justice, Nussbaum (as cited in Schlosberg, 2020) defines capability as the "control over one's environment," and it informs decision-making processes." Since the environmental problems are related to the conditions and values of hegemonic narratives of the modern-industrial-capitalist ways of making and living (Feola, 2020), how capabilities are distributed through 'material-semiotic' arrangements comes into prominence for design for sustainability. With this background, studying alternative ways to relate to nonhumans can point out solidified arrangements that configure the relations that contribute to unsustainable ways of making and living.

Kombucha Fermentation Practices

This section explores the recent research on the microorganisms, kombucha fermentation practices, and related social and ethical meanings. First, I will discuss the overlooked role of the relations between microorganisms, humans, and the environment. Second, I will explain the fermentation practices. Third, I will locate the microbes within societal structures and systems related to sustainability. Fourth, I will focus on kombucha fermentation practices and the multisensory experiences in fermentation. Later, I will explore the interspecies being of human subjects within microbial relations. Finally, I will explore how sustainability approaches microbes.

4. Kombucha Fermentation Practices

All animals are incomplete without the microorganisms that enable metabolic activities for survival (Douglas, 2018, Ch. 1). Recent research on the human microbiome reveals that human health is dependent on microbial diversity in the body and the surrounding environment (Prescott et al., 2018). As discussed in Section 3, the conceptual divide between humans and nonhumans justifies human superiority and contributes to unsustainability. Microbiome research supports this theoretical argument with findings that indicate how human wellbeing is dependent on microbes. Therefore, the central role of microorganisms in sustaining life requires rethinking human-microbe relations and recognizing the interconnectedness among different life forms. The practice of kombucha fermentation serves as a stage to reflect on how human-nonhuman relations are framed through prevailing dichotomies. Although the term 'fermentation' is generally used for referring to human-controlled microbial activities (Kårlund et al., 2020; Doelle, 1975), the microbial activity of decomposing organic compounds is not specific to human practices. The anaerobic metabolism of microbes is an omnipresent activity, but the scientific literature on fermentation focuses on producing knowledge for human practices on the industrial scale. Recognizing the interconnected nature of life and its processes requires challenging the assumptions that separated human beings from natural processes (see Section 3.2).

4.1. Microorganisms, humans, and the environment

The term 'microorganism' refers to single-cell organisms that can form colonies and complex structures (Madigan et al., 2017, p. 38). The category of 'microorganisms' is an overarching category including bacteria, fungi, archaea, and viruses (Douglas, 2018, ch. 2). They have a biomass greater than that of all plants and animals combined (Dale, 2012, Ch. 1). Microorganisms are at the core of metabolic activities of larger organisms such as animals and plants and the ecological processes in general (Douglas, 2018, Ch. 1). Animals sustain their lives thanks to the microbes "involved in the nutrition, health, reproduction, and behavior of their hosts" (Mony et al., 2020, p. 2). The cluster of microbes on a host is called the 'microbiome' (Madigan et al., 2017, p. 37), and the interaction between the host and its microbiome maintains the balance that ensures the host's health (Douglas, 2018, Ch. 3). Recent research on the human microbiome revealed that microbes also influence their host's behavior and mental wellbeing (Cullen et al., 2020, p. 5). To sum up, the physical and mental wellbeing of animals depends on the diet and microbes in the body (Douglas 2018, Ch. 3).

Although microbiome research reveals the pivotal role of microbes on human health, the hygiene hypothesis is concerned with the far-reaching consequences of hygienic lifestyles that impoverish the human microbiome. The modern concept of hygiene includes the assumption that increasing cleanliness improves human health. However, recent research in microbiology has revealed that human health is connected to the microbial diversity of the surrounding environment (Cullen et al., 2020, p. 3), and reduced microbial diversity may cause major allergies and metabolic disorders such as hay fever, asthma, eczema, obesity and diabetes (Grumezescu & Holban, 2018; Douglas, 2018, Ch. 3.5.2). David Strachan was the first researcher who linked the rise in atopic diseases in children with small family size and cleanliness (Strachan, 1989, as cited in

Douglas, 2018, Ch. 3.5.2). These findings revealed that less environmental exposure to microbes, altered diet, and antibiotic use had reduced the human microbiome diversity (Bloomfield et al., 2016). Generally, the reasons behind reduced microbial diversity are related to significant shifts in the lifestyle due to industrialization and urbanization (Rupprecht et al., 2020, p. 9). Therefore, the human microbiome necessitates rethinking human health and recognizing the interconnectedness of human wellbeing with microbes and the surrounding environment.

Furthermore, the interconnectedness between human wellbeing and the microbiome manifests itself in immune regulation. The notion of the immune system "as a protector of 'self against all comers' " is misleading (Douglas, 2018, Ch. 4.1). On the contrary, immune regulation is driven by microbe-host interactions (Bloomfield et al., 2016), and the role of microorganisms is fundamental for the immune system and health (Douglas, 2018, Ch. 4.1). This link between human health and the microbiome diversity indicates that the immune system is integrated with the microbiome rather than isolated (Douglas, 2018, Ch. 4.1). ***The central role of microbial diversity*** for human health indicates the shortcomings of the prevailing assumptions of the modern hygiene concept, which is based on eliminating microbes. Nevertheless, it should be noted that reconsidering hygiene does not frame 'all microorganisms as healthy,' but it challenges the reductionist approach of eliminating all microbial life (Bloomfield et al., 2016). Jamie Lorimer calls this reductive approach the "antibiotic approach to life" (The Kilpisjärvi Collective, 2021, p. 2).

The "***antibiotic approach to life***" also involves controlling the boundaries between humans and microbes by antibiotics (The Kilpisjärvi Collective, 2021, p. 2). Antibiotics have been used to treat infectious diseases, and they have become a major element of the health infrastructure. However, controlling human-microbe relations with antibiotics "has had dramatic outcomes for human and animal health, having led to the rise of antimicrobial resistance" (Kirchhelle, 2020, as cited in The Kilpisjärvi Collective, 2021, p. 2). Antibiotic resistance renders antibiotics ineffective and can make curable diseases risky again because some bacteria have been developing the capacity to evade antibiotics' effects (Landecker, 2016, p. 20). The overuse of antibiotics causes antibiotic resistance, but the root causes of the problem expand beyond the clinical setting. For example, antibiotic use has been a common practice in animal farming practices, including fish farms (Landecker, 2016, p. 20). Animals feed supplemented with antibiotics enable farms to increase their efficiency and profitability (Landecker, 2016). Since efficiency and abundance are crucial for industrial production, "[a]ntibiotic resistance is defined as a collective ecological condition of late industrialism" (Fortun, 2012; Orzech & Nichter, 2008, as cited in Landecker, 2016, p. 19). Moreover, antibiotic resistance is a global challenge that can not be contained within borders; therefore, it indicates that risks and impacts are interrelated in the microbial world (Prescott et al., 2018, p. 8).

The general condition of the disturbed microbiome is called 'dysbiosis" which is the result of antibiotic use other conditions impoverishing the microbiome (Prescott et al., 2018, p. 3). Dysbiosis is associated with numerous metabolic and immunological diseases (Douglas, 2018, Ch. 8.4.1e). "Western lifestyles, including diet, antibiotic use, and excessive cleanliness," are related to the condition of reduced microbial diversity (Douglas, 2018, Ch. 3.6). Specifically, industrial dietary patterns include processed food, food additives, refined fats, high sugar, and residues of antibiotics and pesticides

that cause dysbiosis (Prescott et al., 2018, p. 5; Cullen et al., 2020, p. 7). Although industrial food systems and western lifestyles involve factors that cause dysbiosis, recent research on the human microbiome has begun to indicate how to mitigate the effects of the unhealthy lifestyle. For example, the consumption of probiotics and prebiotics can ameliorate or cure dysbiosis-related diseases (Douglas, 2018, Ch. 3.4.3). As probiotics increase microbial diversity in the gut, prebiotics provides nutrients for the microbes (Grumezescu & Holban, 2018). Fermented foods and beverages are an example of probiotics, and they improve immune functions (Prescott et al., 2018, p. 5). Beyond immunity and metabolic benefits, recent research on gut-brain connection started to explore the positive effects of a healthy microbiome on human psychology (Cullen et al., 2020, p. 5).

Beyond their effects on human wellbeing, microorganisms play a crucial role in transforming materials that support ecological cycles (Mony et al., 2020, p. 2). 'Microbial ecology' deals with microorganisms' effects on the global ecosystem, plants, and animals (Madigan et al., 2017, p. 42). The biomass of microorganisms is superior to that of other organisms, and all ecosystems are strongly influenced by microbial activities (Madigan et al., 2017, p. 42). For example, the oxygen in the atmosphere was made possible thanks to microbial activities (Madigan et al., 2017, p. 38). Moreover, microorganisms are the principal actors in maintaining biogeochemical cycles affecting soil fertility (nitrogen fixation), organic matter decomposition, and carbon storage (Mony et al., 2020, p. 2). Therefore, microorganisms are vital to animal life and life on the planet (Mony et al., 2020). However, particularly in urban areas, human impact results in "non-linear feedback loops that are far from understood" (Cullen et al., 2020, p. 3). Although recent research revealed more details about the central role of microbes in social-ecological entanglements, it is challenging to have a coherent understanding of microbial life (Mony et al., 2020, p. 1). The lack of a holistic understanding might be caused by the fact that human knowledge on microbial relations primarily depends on technologies used in laboratory settings (Madigan et al., 2017, p. 37). Nevertheless, human health depends on environmental health, and the impact of human activities on the environmental microbiome needs consideration. There is a growing recognition of the ***interconnectedness*** among humans, animals, plants, microorganisms, soil, and "the surrounding biosphere, atmosphere, geosphere, and hydrosphere" (Rupprecht et al., 2009, p. 9).

4.2. Fermentation

Fermentation has been an ancient practice of preserving and preparing food and beverages (Kårlund et al., 2020; Dimidi et al., 2019, p. 1). Fermented food and beverages include kombucha, yogurt, kefir, olives, beer, wine, vinegar, miso, pickles, and sauerkraut (Katz, 2003). Traditional fermentation practices have been disappearing from everyday life due to dependence on mass production in industrial food systems (Katz, 2012). However, there is a growing interest in fermentation and fermented foods in recent decades due to touted health benefits of probiotics (Dimidi et al., 2019, pp. 1-2). Moreover, fermentation practices enhance taste and make food more digestible (Fournier, 2020, p. 95; Katz, 2012). With this background, fermentation practices are "materially-driven practices motivated by personal health and medicine, social and cultural tradition, reducing waste, and avoiding mass-production" (Kuznetsov et al., 2016, p. 1786). Within the thesis

framework, I explore fermentation as an everyday practice in which human bodies and microbial bodies are entangled. In this way, fermentation epitomizes a form of multispecies entanglement that links senses, systems, and values with sustainability.

Through metabolic activities during fermentation, microorganisms produce energy from nutrients in environments that lack oxygen. There are two main types of fermentation processes based on the initiation method: wild ferments and culture-dependent ferments. As wild ferments (or spontaneous ferments) involve utilizing the existing microbes in the environment, culture-dependent ferments require the addition of starter cultures that include microbes needed for the fermentation process (Dimidi et al., 2019, p. 2). The produced chemicals vary according to the dominant microbial species (or combinations of species) in the fermentation environment (Redzepi & Zilber, 2018). Figure 2 shows several fermented foods with related substrates produced in the fermentation processes.

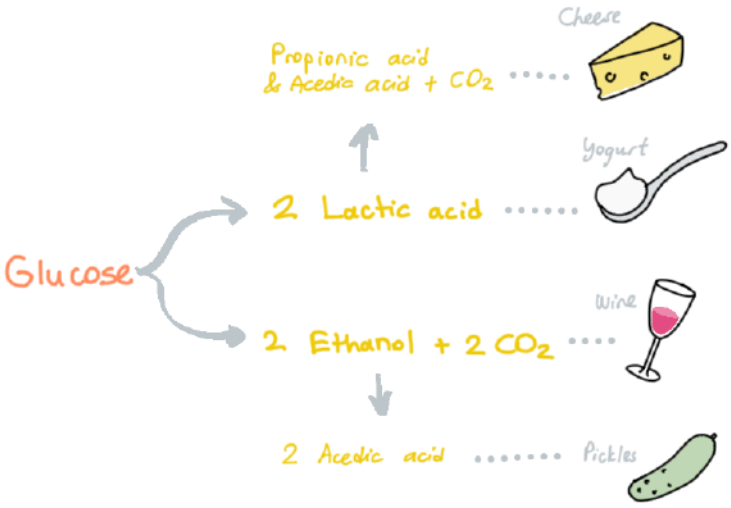


Figure 2. Fermented foods

Note: Adapted from Madigan et al., 2017, p.46

4.3. Kombucha Fermentation

"Kombucha is a soured and lightly carbonated fermented beverage, traditionally made from sweetened tea" (Redzepi & Zilber, 2018). Kombucha is reported to have its origin in northeast China about 220 B.C. and spread to Russia and Eastern Europe (Kapp & Summer, 2019, p. 66). "The word 'Kombucha' is derived from the Japanese words 'seaweed' (Kombu) and 'tea' (cha)" (Ernst, 2003, as cited in Amarasinghe et al., 2018, p. 659). In western markets, kombucha has become popular and commercialized because of touted health benefits (Kapp & Summer, 2019, p. 66). Furthermore, it is possible to brew kombucha with simple tools in domestic areas. I believe that kombucha fermentation and other fermentation practices are becoming more popular among people at the intersection between maker cultures and food culture enthusiasts. Furthermore, the peculiarity of kombucha, caused by its growth and replication, makes sharing kombucha SCOBYs convenient.

Kombucha fermentation is a culture-dependent ferment process that requires a starter culture. The starter culture of kombucha is named SCOBY, a floating biofilm produced by bacteria (May et al., 2019, p. 2). Moreover, it is a "superfluous commodity" (Dolejšová & Kera, 2016, p. 70) that regenerates itself in every fermentation. Therefore, kombucha enables and promotes humans to share the starter culture. Kombucha fermentation is a convenient and easy activity since it does not require special tools. "Almost any liquid with enough sugar can be fermented into kombucha" (Redzepi & Zilber, 2018).

Kombucha fermentation starts with preparing a starter tea with sugar; traditionally, black tea or green tea can be used (Gaggìa et al., 2018, p. 2). The amount of sugar can be adjusted according to

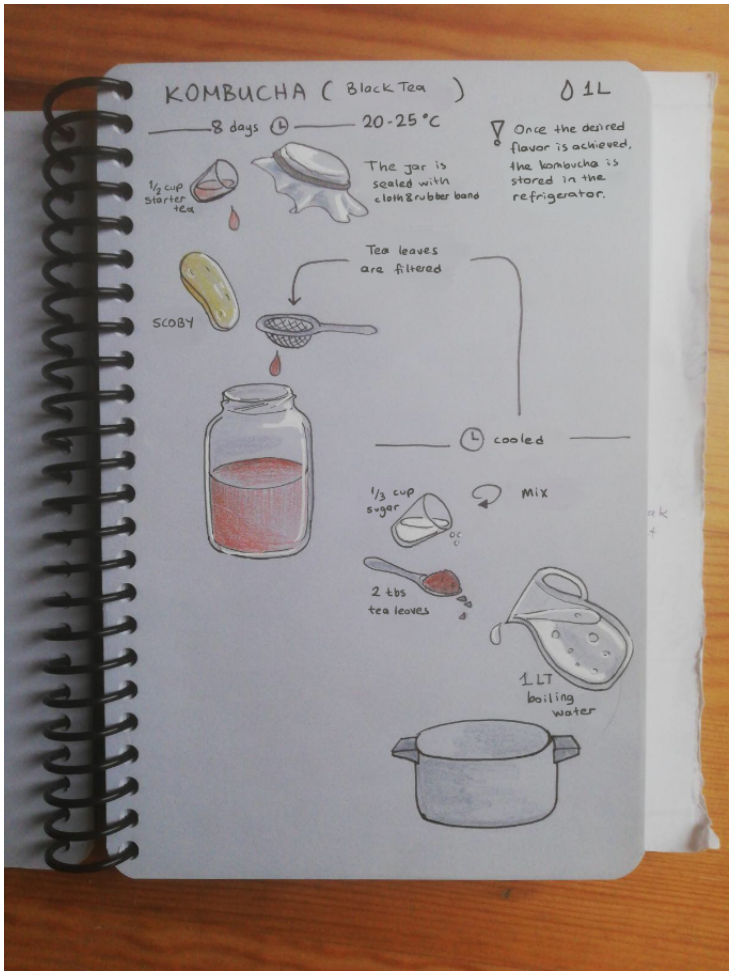


Figure 3. Kombucha fermentation recipe illustrated by the researcher

personal preferences (Redzepi & Zilber, 2018). In order to illustrate the ratio, 200 grams of sugar can be mixed with 800 grams of water (Redzepi & Zilber, 2018). When the tea cools down to room temperature, it is time to add the starter culture, the SCOBY, into the fermentation container (May et al., 2019, p. 4). Ideally, the brewer adds a small amount of fermented kombucha tea from the previous batch (May et al., 2019, p. 4). This step is called backslopping, and it creates an acidic environment suitable for kombucha bacteria (Redzepi & Zilber, 2018). The container holding the kombucha tea should let air transfer because SCOBY needs access to oxygen (Redzepi & Zilber, 2018). The kombucha fermentation process can take 10 to 14 days (May et al., 2019, p. 4). The brewer can adjust the taste of kombucha by adjusting the duration of fermentation, the amount of sugar, and the taste of the tea (Redzepi & Zilber, 2018). During the fermentation process, the liquid's flavor shifts from a sweet and flat liquid to a sour and fizzy one (Redzepi & Zilber, 2018). For increasing carbonation, the kombucha can be bottled through a secondary fermentation process (Redzepi & Zilber, 2018). The residual microbes would continue producing more carbon dioxide for carbonation (Redzepi & Zilber, 2018). After the fermentation, the SCOBY can be infused in a small amount of kombucha tea for storing in a cold place for the subsequent fermentation (Redzepi & Zilber 2018).

The biochemical process of kombucha fermentation involves the symbiotic activity of acetic acid bacteria and the yeast (Redzepi & Zilber, 2018). When SCOBY and sugary liquid meet, the yeast consumes sugars and produces ethanol (Redzepi & Zilber, 2018). The bacteria feed on ethanol and form acidic acid (Redzepi & Zilber, 2018). As the bacteria benefit from the produce of the yeast, bacteria also form floating a biofilm on the surface of the tea; yeast produces the enzymes for the public good of the microbial community (May et al., 2019, p. 4). The acetic acid bacteria lowers pH by producing acetic acid (May et al., 2019, pp. 4-5). The biofilm on the surface of the tea and the low level of pH makes the liquid more inhabitable for the symbiotic community (May et al., 2019, p. 5; Dimidi et al., 2019, p. 8). The composition of kombucha SCOBY and tea varies according to the starting culture, the amount of sugar and tea, oxygen level, fermentation time, temperature, and fermentation duration (Dimidi et al., 2019, p. 8).

The touted benefits of kombucha rely on the general benefits of probiotics and kombucha's proven effects on animals (Kapp & Sumner, 2019, p. 68). Although kombucha's health benefits have not been proven on humans, its reputation relies on the anti-inflammatory and antioxidant

properties of kombucha (Kapp & Sumner, 2019, p. 68). The effect of kombucha on animal subjects informs health improvements in metabolism and digestive systems (Dimidi et al., 2019, p. 8). Furthermore, the categories of fermented food and beverage increase the resilience of the gut microbiome by competing with pathogenic bacteria and producing immune-regulatory substances (Dimidi et al., 2019, pp. 1-2).

4.3.1. Kombucha Fermentation as a Practice

Although fermentation is an ancient practice, it disappeared from households due to dependence on industrial food systems (Katz, 2012, Introduction). With the practice of fermentation, the knowledge of fermentation is also disappearing since generation-to-generation links are broken due to lifestyle changes (Katz, 2012, Introduction). However, kombucha fermentation has been getting more common globally thanks to its touted health benefits, the trends involving the revival of fermentation practices (Katz 2012). Moreover, kombucha has a growing market share (Kapp & Sumner, 2019, p. 66). However, the thesis framework excludes industrial-scale production of kombucha since my interest in kombucha fermentation explores its properties that "counter mass consumption" beyond mainstream industrial food systems (Kuznetsov et al., 2016, p. 1787).

Kombucha fermentation is an easy and open activity that does not require special tools. Having a starter culture, sugar, jar, and tea brewing tools suffices to brew kombucha. Generally, people who are not familiar with kombucha SCOBY feel disgusted by it (Kuznetsov et al., 2016, p. 1792). However, over time, brewers become attached to their kombucha SCOBYs (Redzepi & Zilber, 2018). People who ferment kombucha generally find store-bought kombucha drinks boring (Redzepi & Zilber, 2018). Furthermore, adapting kombucha beverages for the distribution and storage infrastructures of industrial chains might require pasteurization, which eliminates the probiotic properties of kombucha (Spackman, 2018). As the industrial provision of kombucha drinks confines buyers to premade recipes, the kombucha brewers can try new tastes by modifying the recipe and tailoring the beverage to their preferences (Redzepi & Zilber, 2018). Moreover, by lowering the need for packaging and transportation, kombucha fermentation practice enables the brewer to enjoy a delicate drink with probiotics in a sustainable way (Dolejšová & Kera, 2016, p. 70). The most prominent feature of kombucha fermentation is its SCOBY, which grows during the fermentation process. The SCOBY mat is the health indicator and visual cue for the brewers (Redzepi & Zilber, 2018). The conspicuous growth of the SCOBY contributes to the metaphor of 'fermentation as a mode of communication' (Hey, 2019b, p. 150) among humans and microbes, making kombucha fermentation a multispecies activity that is carried out by human subjects and the microbial community.

4.4. Interspecies Being

Within the thesis, I explored kombucha fermentation as a stage to reflect on human-nonhuman relations. However, the existing literature on microbiology involved fragmented knowledge that did not relate to alternative ways of relating to nonhumans. Therefore, I felt the need to involve an expert interview that can guide my ambitions of connecting human-nonhuman relations to ethics and sustainability. For this, I reached out to Salla Sariola, a lecturer

at the University of Helsinki, studying and teaching microbes in the context of sociology, ethics, feminist technoscience, antibiotic resistance, and global healthcare. The personal communication with Salla Sariola provided insights that guided me to explore the "microbes as social actors" (personal communication, March 2, 2021). Although microorganisms are related to the vital processes that influence society, established modes of approaching microbes in scientific knowledge lack the recognition of symbiotic perspectives to microbes (S. Sariola, personal communication, March 2, 2021). For example, microbes are discovered within contexts related to contagious diseases and food contamination, and therefore, eradicating microorganisms has been the primary goal in public health (S. Sariola, personal communication, March 2, 2021). However, recognizing the symbiotic and holobiont perspective to microbes challenges established modes of thinking, "therefore, bringing a different way of asking questions about ecologies, bodies, relationships, and relationalities." (S. Sariola, personal communication, March 2, 2021). Nevertheless, the possible implications of challenging established ways of thinking about microbes are far-reaching and waiting to be explored (S. Sariola, personal communication, March 2, 2021). The abiotic approach to microbes is systemic, and antibiotics are like an invisible 'infrastructure' (Willis & Chandler, 2019).

As the interview with Salla Sariola revealed, "microbes as social actors" require new fields of knowledge that can emphasize the agency of microbes in society and ecology. The need for challenging established ways of thinking also manifests itself around the boundaries of humans. The microbial world includes entangled relations in which the boundaries of individual humans are not clear. For example, the human microbiome acts as an active agent of the immune system (Bloomfield et al., 2016; Douglas, 2018, Ch. 4.1), and antibiotic resistance connects all human bodies by exposing society to an interconnected and contingent risk (Landecker, 2016, p. 22). Therefore, microbiology reveals that the human body is biocultural (Fournier, 2020, pp. 97-98). In this way, microbial relations epitomize the necessity to develop a framework for multispecies sustainability (Rupprecht et al., 2020, p. 9) and a new type of social science (The Kilpisjärvi Collective, 2021, p. 1). Although entangled microbial relations indicate a need for a paradigm shift in epistemologies, fermentation can be a stage for experiencing multispecies entanglements because fermentation connects different bodies (Hey, 2019b, p. 150).

A notion of wellbeing based on the interconnectedness of human beings and nonhuman beings requires dismantling the human/nonhuman divide (The Kilpisjärvi Collective, 2021, p. 3). According to Barad, defining the borders of humans is political and ethical (as cited in Hey, 2019b, p. 154). Since politics in microbial relations can be considered a model of environmental relations (Fournier, 2020, pp. 97-98), an alternative definition of human-microbial relations has an ecological dimension (The Kilpisjärvi Collective, 2021, p. 3). The political and ethical meanings point out refusing essentialism (The Kilpisjärvi Collective, 2021, p. 3), leaving individualism, anthropocentrism, the idea of purity (Fournier, 2020, p. 108). On the microbial level, fermentation practices can enable exploring an ethical way of being together in a multispecies relationship (Fournier, 2020, pp. 108-109). According to Fournier (2020, p. 102), the ethics of fermentation "foregrounds care -of the self and others."

Kombucha fermentation practices rely on ***senses for knowing*** microbes (The Kilpisjärvi Collective, 2021, p. 8). For example, brewers check the thickness of the mat and the smell of the tea to troubleshoot

the fermentation process (Kuznetsov et al., 2016, p. 1794). Moreover, brewers might adjust fermentation duration by tasting the tea. The senses and learnings on multispecies interaction inform embodied knowledge which imprints sensory information with memories (Hey, 2019b, p. 153). With the smell indicating the situation of the fermentation process, brewers continuously assess the state of a ferment (Hey, 2019b, p. 153). Kombucha fermentation practices involve hands-on experimentation as a way of learning about and attuning to the needs of microbial communities (Kuznetsov et al., 2016, p. 1792). Therefore, fermentation is a "mentally manual activity" where senses and body act as a pathway to the human subject (Heldke, 1992, as cited in Hey, 2019b, p. 152). Salla Sariola also ***informed embodied way of knowing*** with an anecdote on fermentation. Sariola (personal communication, March 2, 2021) mentioned one of her latest researches about sourdough fermentation practices in which she talked to people who bake bread. The baker was adjusting fermentation according to temperature and environmental conditions guided by embodied knowledge. Although the baker did not have the information about the chemistry of fermentation, her skills and embodied knowledge about fermentation practices were enough to carry out fermentation by adapting to conditions (S. Sariola, personal communication, March 2, 2021). I interpreted this anecdote as a story to highlight the relevance of diverse imaginations for recognizing microbial relations. According to the Kilpisjärvi Collective, fermentation activities are situated, embodied, and multisensory practices (Law & Mol, 2008, as cited in The Kilpisjärvi Collective, 2021, p. 7) which engage with 'arts of noticing' (Tsing, 2017, as cited in The Kilpisjärvi Collective, 2021, p. 7).

Being embedded in the fermentation practices and being proximate to nonhumans make humans accountable towards other life forms (Hey, 2019b, p. 154). On the contrary, within industrial food chains, humans have severed connections with the production of food and the affected nonhumans (Katz, 2012). While Fesmire (2010, p. 184) calls this condition "***aesthetic disconnection***" from industrial food chains, Schlosberg (2020) calls it "alienating" since consumers do not meet with the land or producers. Within the context of my thesis, I situate kombucha fermentation practices as an alternative to alienating ways of relating nonhumans. As this stance is informed by the learnings from relational approaches (see Section 3), I focus on the interdependent wellbeing of humans and nonhumans (Rupprecht et al., 2020), the reciprocal constitution in relations, and being accountable for nonhumans. While this intended questioning established ways of thinking for sustainability, it also required an inquiry towards the manner of sustainability towards microbes.

4.5. Microbes, Industry and Sustainability

My literature search also explored how design and sustainability approach microorganisms. Using a bibliographical analysis tool, I extracted the most used keywords from the titles of the search results addressing microorganisms within sustainability research (see Appendix D). The results included keywords like "technology", "production", "microalgae", "biomass", "biofuel", "pollutant", "soil fertility", "diversity", "plant growth", "application", "system", "effect", "bacterium", "wastewater treatment". The keywords implied that the approach of sustainability to microbes predominantly represents an ***extractive*** and instrumental manner, as of the values of industrial production and capitalism. This manner can be explained by

dominant scientific-oriented discourses within sustainability research guided by market forces (Feola, 2019). However, this also reveals that the sustainability research has not yet decoupled from extractivist tendencies of industrial mindset and market logic. As knowledge is constructed through power relations (Foucault, 1980, as cited in The Kilpisjärvi Collective, 2021), the scientific knowledge frameworks are also influenced by the value systems that they are embedded in.

In the industrial context, microorganisms are grown on massive scales to produce antibiotics, enzymes, and certain chemicals (Madigan et al., 2017, p. 45). For example, biotechnology employs genetically engineered microorganisms to synthesize high-value products such as insulin (Madigan et al., 2017, p. 45). However, beyond the production of microbes and compounds, eradication of microbes is a goal for some sectors, like food supply chains and animal farming (Landecker, 2016, p. 20). Within the vast infrastructures, the microbial bodies are controlled for production or eliminated by sterilization. The dualistic approaches reproducing human superiority renders microbes controllable (Hey, 2019b, p. 153). Although it is difficult to estimate the far-reaching ethical implications of microbial relations, including and excluding things produce different realities and posit ethical questions (Barad, as cited in Hey, 2019b, p. 151). For example, hygiene hypothesis and antibiotic resistance had been 'alternative realities' that once involved risks for human health and were made possible by the mismanagement of microbial bodies. Microbiopolitics inform that power and biological life are intertwined, and microbial relations should not be situated within capitalist relations of power (The Kilpisjärvi Collective, 2021, p. 6).

Empirical Learnings

In this section, I will explain the empirical learnings that emerged from interviews and a collective kombucha fermentation activity. This section outlines the empirical research and learnings in three sections. First, I will provide the learnings from the interviews on kombucha fermentation practices that I have conducted with kombucha brewers from my social sphere. Second, I will reveal the insights that emerged from an expert interview about the social aspects of fermentation and microbiology. Third, I will summarize the collective kombucha fermentation activity by exploring human and nonhuman relations during kombucha fermentation practices.

5. Empirical Learnings

The empirical research explored how fermentation practices can open up a space for recognizing relationality with microorganisms. The interviews, conducted between December 2020 and February 2021, explored the personal fermentation journeys of three kombucha brewers from my social sphere (P1, P2, and P3). The collective kombucha fermentation activity involved four participants ((P1, P2, P3, and P4) and the researcher (R). Moreover, my personal experience on kombucha fermentation enabled me to have personal insights about fermentation practices and supported my intuition through empirical research.

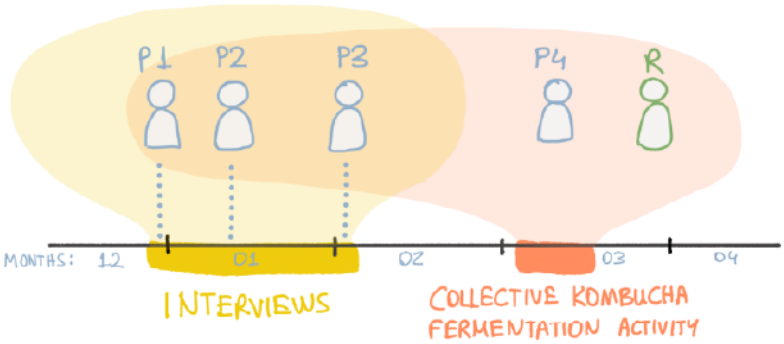


Figure 4. The empirical research timeline including the participants

Note: The letter "P" refers to participants, and "R" refers to the researcher.

5.1. Interviews on Fermentation Practices

Interviews on fermentation practices explored topics that emerged from the literature on fermentation practices (see Section 4) and the concept of relationality (see Section 3). Since the conceptual framework of the thesis stemmed from relationality, I intended to examine human-microbe interactions and the agency of these interactions during fermentation. I interviewed participants through online video calls that lasted about 45 minutes. Despite having predefined themes and questions, I preferred to keep the structure of the interview process and questions open for having explorative interviews.

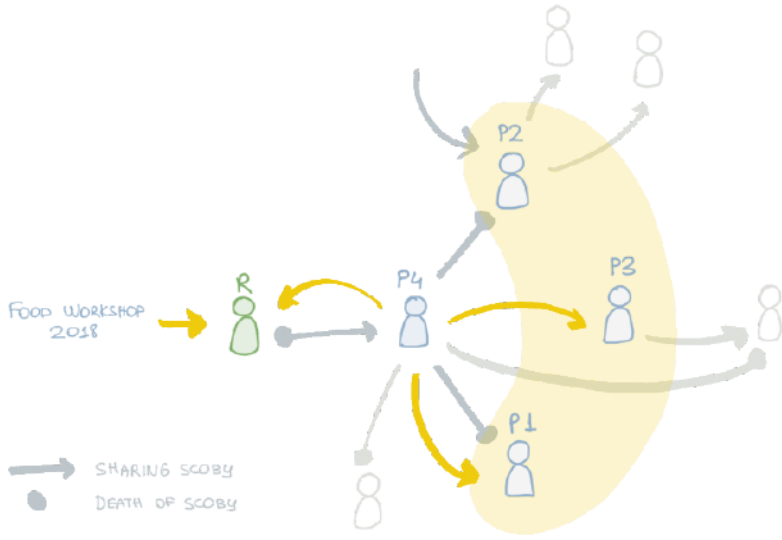


Figure 5. The network of SCOBY sharing among participants

Note: The yellow area contains the interview participants.

5.1.1. Participants and the Interview Process

As mentioned in Section 1.1.1, I selected participants from my personal social sphere for the interviews on kombucha fermentation practices. The network of

sharing kombucha connected us thanks to an inch of SCOBY that I obtained from a food workshop during the 2018 Istanbul Design Biennial. Since kombucha SCOBY grows and replicates itself, one can share it with interested people. Figure 5 portrays the sharing network of kombucha SCOBY among participants.

Kombucha sharing activities among participants took place in the context of daily relationships, regardless of the provision of empirical teachings for the thesis. Participants fermented kombucha for a varying period of three months to three years. The dots in Figure 5 represent the spoilage of kombucha SCOBY. Despite spoilage, brewers generally maintain fermenting kombucha thanks to their relations with other people who grow kombucha.

5.1.2. Defining Interview Themes and Questions

The interviews aimed to explore human-microbe relations within kombucha fermentation practices. Since these relations are experienced on a material level, the interviews focused on experiential, practical, and sensory aspects of interactions. Figure 6 shows a section of the mindmap used for the integration process to identify overarching themes and guiding questions. The themes and guiding questions emerged from the learnings from the literature search on relationality (see Appendix E) and the learnings from the literature search on kombucha fermentation practice (see Appendix F). I prepare the guiding questions not for asking these questions to participants but for guiding the interview questions. Finally, I prepared the original interview questions but reviewed the interview questions after each interview to make minor changes based on emerging themes and ineffective questions (see Appendix H).

Figure 7 outlines the themes and guiding questions that steered the interview questions. The guiding questions and themes emerged from grouping learnings from literature research into categorizations. These categorizations implied relevant learning domains such as; personal journeys of brewers, practice level learnings, and ethical meanings. Although the themes varied from a practical level to an ontological level, the interview did not thoroughly explore all the themes. It was challenging to address abstract themes with interview questions because the focus arose from everyday-ness and microbial relations' tangibility. In brief, it was not possible to discuss political, ethical, and ontological meanings with participants during the interviews. As a result, the interview questions mainly provided insights about practical and sensory levels (see Appendix H). With the interview questions, I explored the participants' journey of fermentation, practical aspects of kombucha fermentation, and sensory elements of the interaction such as seeing, smelling, and touching. Moreover, some of the questions addressed feelings and thoughts related to fermentation practices, sharing SCOBYs, and traditional fermentation practices.

5.1.3. Learnings from the Interviews

After each interview, I transcribed the interviews and noted the learnings by listening to the audio recordings. The responses provided insight into the practical aspects and sensory experiences of fermentation practices. The insights were about the participants' personal kombucha journeys, the generic steps of kombucha fermentation, sensory experiences, care, ethical and social meanings of fermentation practices.

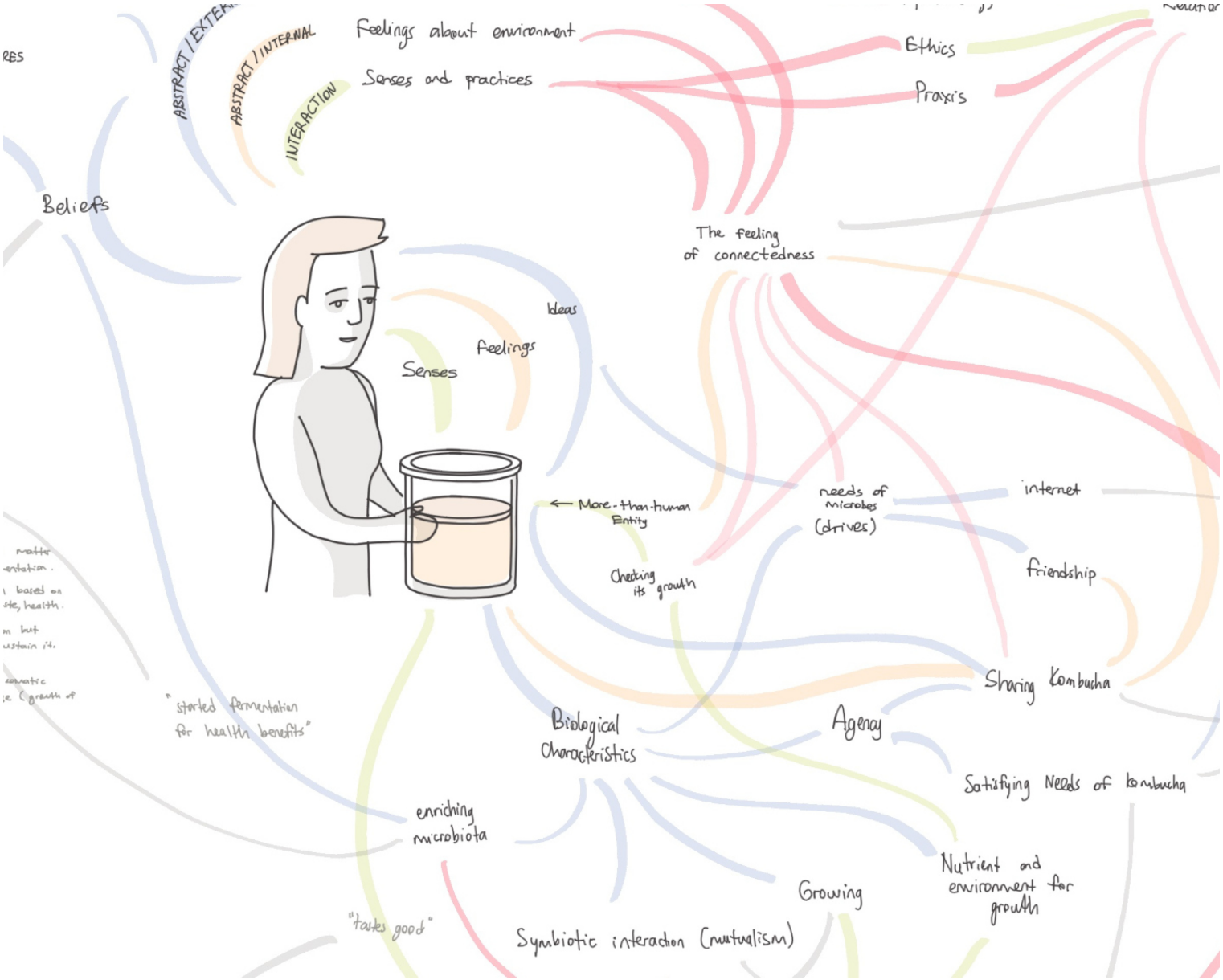


Figure 6. A section of a mindmap for integrating learnings

Note: The learnings are connected to the varying themes of human-microbial relation during kombucha fermentation processes. The learnings emerged from the literature search, learning diaries, and personal experiences. (see the Appendix G for the entire mindmap)

All of the participants ***started kombucha fermentation due to health concerns***. Two participants suffered from immune-related disorders, and one of the participants had discomfort about her digestion system. Participants expected that kombucha would improve their immune system and metabolism in general. After hearing the touted health benefits, they were interested in drinking kombucha regularly.

P1: Having immunity disorder, she started fermenting kombucha for improving her health more than one year ago. However, she did not develop a rhythm of kombucha fermentation and she was fermenting kombucha occasionally. She finds the long preparation time challenging. However, she was keeping the kombucha alive during the interview.

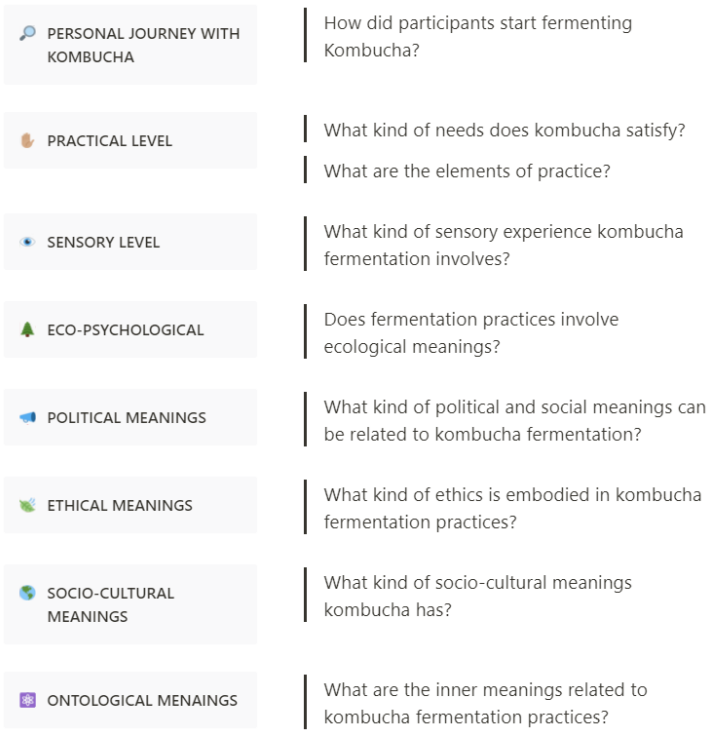


Figure 7. The themes and guiding questions for preparing interview questions

P2: For relieving her digestive metabolism, she started kombucha fermentation about two years ago. She developed a rhythm of fermentation with two different kombucha batches every week respectively.

P3: She suffered from an immunity-related disorder (Hashimoto), and one of her friends with the same health disorder had mentioned that kombucha improves health. Therefore, P3 started drinking store-bought kombucha beverages. However, it was challenging to find bottled kombucha since kombucha was not common in groceries in Turkey. Consequently, she started fermenting kombucha by obtaining SCOBY from P4 three months ago.

The participants ***cared for the kombucha SCOBY*** because of the benefits kombucha provides. P2 and P3 were highly enthusiastic about its taste.

P1 was keeping kombucha SCOBY alive even she has not been fermenting it for a long time.

P2 mentioned that she sees kombucha as a living thing. Even though she had spare SCOBYs, contaminating one of SCOBYs made her feel bad. She also mentioned that being able to drink the produce of a growing/living thing is very interesting.

P3 mentioned that kombucha is a self-care activity at the same time. It is spending time for yourself and your health.

The fermentation process includes **sensory experiences** involving visual, olfactory, and gustatory senses. Senses are used to troubleshoot the fermentation process. During fermentation, participants generally check the growth of the SCOBY to be sure about its wellbeing. The smell of fermented tea is another indicator for ensuring the health of fermentation.

Since kombucha grows in each fermentation cycle, participants were ***encouraged by SCOBY to share*** it after several fermentations.

P1 felt an urge to share kombucha because the SCOBY grows. However, due to Covid-19 pandemic, she could not find opportunity to meet friends and share her SCOBY.

P2 shared her kombucha with several people. She mentioned that some people might find kombucha SCOBY disgusting at first, but after tasting it and learning its benefits, they consider trying it.

All of the participants showed interest in ***trying new recipes*** for kombucha fermentation. Participants adjust the sugar level and change the type of tea they are using for the base liquid. In this manner, kombucha is open to changes in the recipe.

The participants have not been engaged in other types of fermentation activities. They think that kombucha is very ***different from traditional fermentation practices***, which involve yogurt, bread, and pickles in Turkey's

traditions. However, participants were not sure about the main reasons for defining it as a distinguishing activity. Kombucha was described as interesting and unusual (even exotic) by participants. Starting kombucha fermentation for its touted health benefits may explain not engaging in other kinds of fermentation activities.

The interviews enabled me to understand the personal journeys of the participants and their fermentation scenarios. The level of discussions was on an everyday level for exploring the elements of the fermentation practice. Therefore, we could not explore the feeling of connectedness in human-nonhuman relations and the abstract concepts related to fermentation. The level of insights about the social side was also minimal, despite some learnings about sharing SCOBY and learning its touted health benefits from friends. The social and ethical aspects of kombucha fermentation would be addressed extensively in collective kombucha fermentation activity.

5.2. Collective Kombucha Fermentation Activity

In the Collective Kombucha Fermentation Activity, participants fermented kombucha simultaneously. The activity primarily aimed to open up a space for recognizing the agency of microbes during kombucha fermentation practice. For this, I outlined a probing activity and asked the participants to create their own recipes with fermentation steps and jot down their thoughts, feelings, and observations related to the fermentation experience. I compiled the recipes of participants into a board to enable participants to reflect on fermentation practices collectively. The activity started with an online meeting on March 5 and ended with a facilitated reflection workshop on March 20. In the final reflection workshop, five participants, including me, shared their experiences by reflecting on the fermentation experience through notes from participants' recipe notes (see Figure 8).

5.3.1. Designing the Activity

The Collective Kombucha Fermentation Activity explored several aspects of human-microbe interactions during fermentation practices. The focus of the activity involved the agency of microbes, the ethics of care, and sensory experience within fermentation practices and knowledge sharing among participants. These themes stemmed from the learnings from the interviews and literature review on fermentation and relationality. The literature on relationality guided me to explore the agency of nonhuman entities that are microbes in the context of fermentation practices. The idea of interconnectedness and emergence stemming from relationality contributed to the concept of ethics of care emerging from relations.

Furthermore, the literature on fermentation informed the role of sensory experiences in fermentation. With these objectives, I designed an activity to enable participants to delve into and reflect on kombucha fermentation practices. While the design probe activity of writing a recipe enabled participants to delve into the practice, the final reflection meeting enabled participants to reflect on their fermentation practices.

5.3.2. Kombucha Recipes as a Design Probe

To enable people to recognize the symbiotic interaction with the kombucha culture, the researcher aimed to provide the opportunity to think about the practice of kombucha. For this, the participants were asked to prepare a kombucha fermentation recipe on

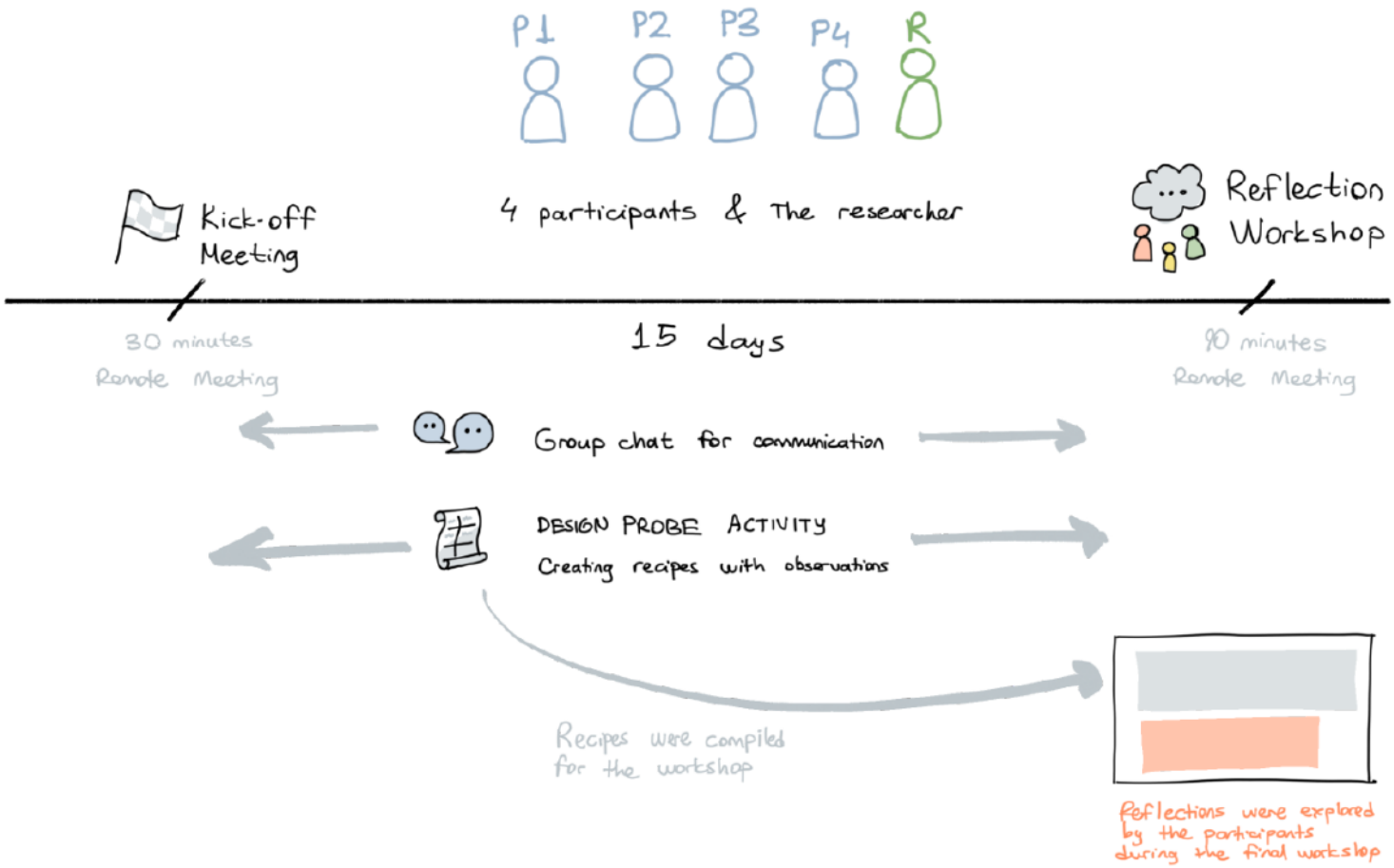


Figure 8. Process design of collective kombucha fermentation activity

paper by noting down reflections about the process. The design probe activity aimed to enable participants to capture the elements of human-microbe interaction. During the kick-off meeting, I presented a simple recipe template that includes two columns on a page. On the left column, the fermentation steps would be listed by the participant. The right column had the title "Observation, emotion, thought" that asked participants to delve into the fermentation steps. The fermentation steps were not conceived as limited only to actions of adding or removing ingredients but also troubleshooting the fermentation process, which is an important part of fermentation activity. After finishing a whole kombucha fermentation period around eight to ten days, the participants sent the photographs of their recipe notes to the online group chat and I grouped the notes into themes (see Appendix I). I compiled these notes and grouped them on a board according to fermentation steps for the reflection meeting.

5.3.3. Reflection workshop

The final workshop involved a reflection session on the fermentation practices based on the recipe notes participants wrote during the Collective Kombucha Fermentation Activity. Since the activity design aimed to understand the agency of microbes within the entangled human-microbe relationship during fermentation, interconnectedness has been a significant goal for the activity. Although the concept of interconnectedness is abstract, I believed that I could address it within the embodied and sensory ways of knowing. I assumed that the agency of microbes would have shaped the embodied knowledge through sensory experiences. Therefore, the reflection workshop was based on the interpretation of embodied ways of knowing and sensory experiences. Exploring embodied knowledge

and sensory interaction in an online activity seemed challenging at first. However, online activity enabled participants to produce the data in their own environment. Furthermore, it opened space for self-observations and immersing into the fermentation practice individually.

The need for reflection on microbial interaction stemmed from a normative aim of recognizing the interconnectedness and the agency of microbes in fermentation practices. I did not explicitly mention the normative goal until the reflection workshop but the goal guided the design of the activity. For example, recognition of the interconnectedness required participants to delve into the interaction with kombucha SCOBY. Because of this, I prepared a board that includes the fermentation steps and participants' observations, thoughts, and feelings about the kombucha fermentation practices. Moreover, during the reflection workshop, I overviewed the compiled fermentation notes of the participants. The overview enabled participants to refresh their memories about the microbial interaction. We tried to understand how we experienced the interconnectedness with microbes during kombucha fermentation practices through the compiled fermentation notes. This understanding stemmed from an inquiry into the ways fermentation actions were shaped by the needs and wellbeing of the kombucha SCOBY.

5.3.4. Insights on the Activity

Through the collective fermentation activity, participants' observations and collective reflection unfolded the feeling of interconnectedness. During the interviews, most of the participants expressed that they see fermentation as a mundane activity without referring to the vitality and agency of microbes. Yet, group interaction within the study changed how participants approached the fermentation activity. Since the collective kombucha fermentation activity and the group interaction created a space to delve into the synergies within kombucha fermentation practice, participants started to identify the vitality and agency of microbes within kombucha fermentation practices. Furthermore, the activity revealed the embodied ways of knowing and sensory experiences informing relational ethics.

Interconnectedness

As the activity opened a reflexive space to think about the practice of kombucha fermentation, participants found an opportunity to relate their actions to the well-being of the non-humans. Providing food and a proper environment for the microbes have been the central theme in the recipes and reflection workshop. As fermentation involves caring for the kombucha, the practice refers to the feeling of responsibility for microbes. For example, cleaning the fermentation tools, avoiding touching the SCOBY by hands, and keeping the fermentation jar in a dust-free space arise from the goal of providing a healthy living environment for fermenting microbes. Although initially, the reason for keeping SCOBY healthy originated from the expectation of benefiting from it, participants had developed a feeling of connectedness with their SCOBYs over time. As this attachment informs, the relational value was evident in the recipe notes prepared by P4. She reflects on the necessity to keep SCOBY healthy even though she had spare SCOBYs. Another example is P1's discomfort about the idea of frying and eating kombucha. These reflections inform the feeling of interconnectedness developed through proximity with microbes over time.

> "The older kombucha is growing slowly. I should have checked it before using

stevia... Even though it is old, its survival is important. Don't leave it starving deliberately." (written by P4 as a recipe note, translated from Turkish)

"P4 talked about the idea of frying and eating [kombucha]. Initial I found it interesting, but later I could not help thinking that it was like taking its life" (written by P1 as a recipe note, translated from Turkish)

Everyday contingencies and sharing

During the activity, the participants also influenced each other by sharing knowledge, incidents, and experiences. For example, P1's SCOBY was spoiled during the activity. After learning about this incident, another participant, P3, noted that she was more attentive about her SCOBY. After the spoilage, P1 started a new fermentation using the SCOBY she obtained from P4. Therefore, the group decided to extend the activity duration from nine days to fifteen days to allow P1 to keep up with the group and participate in the next steps of the activity. Although P1 obtained SCOBY thanks to her friend P4, P2 did not have this chance. P2's SCOBY had spoiled before the collective kombucha fermentation activity due to her partner's mistake. However, having just moved to another country, she could not obtain a kombucha SCOBY from another friend. Therefore, she bought a kombucha SCOBY from an online pharmacy shop. P2 mentioned that she would obtain SCOBY easier if she were in her hometown, thanks to the people who previously provided SCOBY from her. The incident revealed that when people share kombucha SCOBY, they also secure their future SCOBY supply. In the empirical research, sharing of kombucha related to everyday contingencies at different levels and informed the agency of relations in kombucha fermentation practices.

"I heard that P1's SCOBY has spoiled. When I read what she [P1] wrote, I checked mine immediately. I was afraid it would get mold. I washed my hands. I took the old SCOBY which was under the other one. This was the first time I needed to intervene. I am afraid about spoiling it due to touching too." (written by P3 as a recipe note, translated from Turkish)

Agency of relations

Another interesting insight arose from a conversation about knowledge sharing during the reflection workshop. Participants recognized that they have taken for granted the knowledge learned from P4, who shared her SCOBY with other participants in the past. Participants realized that they maintain some of the insufficient information originated from P4. While sharing the kombucha SCOBY, she also shared the knowledge that SCOBY should be stored in the fridge with a cloth cover when not fermented. However, P2 mentioned that she bought a kombucha SCOBY in a closed jar. Thus the group realized that kombucha SCOBY could survive even its container does not breathe. This story revealed that other participants still applied the knowledge they took from the SCOBY provider. Here, the sharing of the SCOBY on the material level was tied to the immaterial knowledge of fermentation. The connection between matter and knowledge has been revealed thanks to this conversation. Furthermore, the participants related this kind of knowledge transfer to the traditional knowledge, which passes from generation to generation. In the context of fermentation, the previous generation refers to the person who shares the kombucha with others. To summarize, the one who shares kombucha also shared the knowledge of fermentation.

Embodied knowledge

Participants' recipes included many instances of personally developed methods. Participants had enhanced their fermentation skills by inventing their tricks and methods. Sensory experience and embodied knowledge informed the selection of tools, the execution of steps, gestures, troubleshooting the condition of liquid, and fermentation. Furthermore, participants needed to develop minor fixes to the difficulties during fermentation. As mentioned in the interview with Salla Sariola (see section 5.2), the knowledge of the chemical processes of fermentation is not necessary to adjust fermentation to changing situations. In the collective kombucha fermentation activity, participants were able to make adjustments to recipes and fermentation steps with the embodied ways of knowing. Therefore, embodied way of knowing informed fermentation practices and enabled participants to enhance their fermentation practices.

Sensory experience

In recipe notes and reflection workshop, participants informed the sensory aspects of the experience in several fermentation steps. As the fermentation steps section of the workshop board shows (see Appendix J), participants collected sensory information about the fermentation process through seeing, smelling, tasting, and touching. The sensory experience relates to the embodied knowledge in several ways. First, sensory experience enables participants to attune their actions through fermentation. For example, P4 measures the temperature of the tea by soaking her finger in the tea. Second, sensory experience provides the long-term learnings that contribute to embodied knowledge. For example, P1 started adding less sugar than usual because she did not want to feel the taste of sugar in the end product. Another learning example related to sensory experience was about managing the fermentation duration. Participants knew that extending the fermentation duration rendered the beverage sourer by lowering the level of sweetness. Therefore, the senses become tools for evaluating taste, acidity, measuring temperature, assessing microbial growth, and measuring the volume of ingredients. Senses provided feedback from microbes during the fermentation processes and created the knowledge and emotions of the participants.

> "If the taste of sugar remains in a fermented kombucha, it means that bacteria could not have used all of the sugar." (a note from the collective reflection board, translated from Turkish)

Relational ethics

The embodied knowledge and know-how are central in fermentation practices. Participants have mostly obtained the knowledge of fermentation through informal knowledge transfer. Still, later, as they experienced fermentation, they developed their own methods and tricks by relying on their senses and embodied knowledge. In my opinion, this informs a relational way of knowing in which knowledge is grounded on relations, other knowledge, and embodied ways of knowing about other beings. Beyond the knowledge embedded in the practice, participants also developed their own ethical conduct and performed ethical behaviors unwittingly. The sensory experience and embodied knowledge constitute the relational ethics emerging from the relation with microbes. I listed the appearances of relational ethics among the occurrences from the collective kombucha fermentation activity below:

- P4 tried to use stevia instead of sugar for kombucha fermentation. However, the fermentation was not progressing as expected. She added sugar to the

fermentation jar when she learned that stevia might not be a food supply for kombucha microbes. Although she had more than one SCOBYs, she cared for each SCOBY without leaving any of them starving to death.

- After having a spoiled SCOBY, P1 took a new SCOBY from P4. When P1 wrote about the new SCOBY, she wrote that "I can't call it my kombucha still. I don't feel like it belongs to me". This feeling informs the attachment between the participant and the microbial community.

- Participants had many concerns about keeping kombucha SCOBY healthy and undisturbed. Some of these were informed by general knowledge about kombucha fermentation, such as keeping it in a dustless and dark place, cleaning the tools, and not exposing kombucha to heat. Furthermore, participants also developed their conduct of caring kombucha in a sensitive way. For example, placing SCOBY next to other foods, being afraid of using torchlight to check its growth were some concerns that participants developed by themselves.

To sum up, embodied ways of knowing and sensory experiences supported the practice of caring for kombucha SCOBY. Consequently, the interaction with microbes seemed to have resulted in the ethics of care and relational ethics (see section 3.5).

Flexible, durable, and forgiving

During the reflection workshop, participants characterized kombucha as a strong culture, making kombucha fermentation a flexible and forgiving practice. A participant mentioned that "kombucha is a strong bacteria, and it is not like kefir, which dies easily." Since kombucha overcomes minor mistakes, the microbial community is durable and can survive as long as a strong mold does not contaminate it. Participants have been trying different tea bases and spices to personalize the taste of the beverage. Moreover, they can develop quick fixes if minor challenges emerge. In this manner, kombucha is a forgiving companion which gives space for experimentation. Having the knowledge and feeling of the durability of kombucha SCOBY, participants feel confident when trying new recipes and creating their own methods of caring for kombucha SCOBY.

Open and simple

Furthermore, kombucha fermentation practices do not require special tools. The material configuration for fermenting kombucha is simple and open. When participants lacked some types of equipment, they easily replaced the missing tools with others. For example, P1 mentioned that she could not find the cloth she generally uses for covering the jar's mouth. Then, P1 used a paper towel to cover the jar. Other participants have also improvised and adapted fermentation steps by replacing tools if needed during their fermentation journeys. Knowing that kombucha is durable allows improvisations during fermentation. In this way, the characteristics of kombucha shaped the practice of fermentation and the participants' knowledge and feelings.

Findings

In this section, I integrated and analyzed the learnings from the literature review and empirical research regarding the research questions (see Section 2.1). Through the findings section, I explored how kombucha fermentation practices opened up space for recognizing relationality with nonhumans; how attunement occurs within human-nonhuman relations through sensory experiences and embodied knowledge; how relational ethics sustain human-nonhuman relations; and in which ways relational approaches can ground values within relations in the context of design for sustainability.

6. Findings

This section groups the learnings from the literature search on relationality (see Section 3), kombucha fermentation practices (see Section 4), and the empirical research on kombucha fermentation practices (see Section 5). The literature search on relationality and kombucha fermentation practices provided theoretical and factual learnings about the topics. The empirical research provided experiential learnings about kombucha fermentation practices thanks to interviews and the collective kombucha fermentation activity. These learnings are analyzed through the lens of my background on kombucha fermentation, design, sustainability, and critical theories.

As I mentioned in Section 1, focusing on relationships among humans and nonhumans could enable the sustainability field to transcend the established conceptual boundaries that limit knowledge. Therefore, my ambitions involved an emphasis on the blurry borders between human and nonhuman entities on a conceptual basis. Beyond blurring the boundaries among entities, relational approaches inform reconsidering the divisions between epistemological categorizations (see Section 3.3). Therefore, the findings section freely revolves around the categories of knowledge related to humans, nonhumans, and sustainability. The concept of material-semiotic entanglement from feminist research also encouraged me to horizontalize different categories of knowledge in this section. Therefore, within the thesis framework, the definition of sustainability lies in relationships transcending systems, societal structures, ecologies, inner meanings (Ives et al., 2020), values, and ethics. Moreover, this kind of approach relates to an intuitive and creative way of developing connections for knowledge production about difficult-to-grasp relations. However, this approach could jeopardize the validity of the research when compared to classical reasoning methods. However, undisciplined thinking can be a strength in design research for adopting explorative, creative, and critical theorizing (Gaver, 2016, p. 193).

The section is organized into four sections regarding the research questions listed in Section 2.1. With the research questions, I aimed to reflect on design for sustainability through the theoretical concept of relationality and the empirical experience of kombucha fermentation practices. The research questions are set out below.

1. How can kombucha fermentation practices open up space for recognizing relationality with nonhumans?

2. In which ways human-nonhuman entanglement steers kombucha fermentation practices?

3. What kind of ethics sustain human-nonhuman relations within kombucha fermentation practices?

4. In which ways can relational approaches ground values within relations in the context of design for sustainability?

6.1. Opening up space for recognizing relationality with nonhumans

The interviews revealed that participants started brewing kombucha due to health concerns, and they continued caring for their kombucha SCOBY (see Section 5.1.2). The sensory experience of smelling, seeing, and tasting enabled the participants to ensure the wellbeing of the SCOBY. Since interviews had the goal of understanding the experiences of participants, the language of interviews was on the everyday level.

Therefore, abstract themes like relational ethics and the feeling of interconnectedness were not elaborated during interviews. However, the collective kombucha fermentation activity enabled us to delve into the practice of kombucha fermentation by exploring meanings and feelings in depth. For example, the recipes that participants prepared included the feeling of attachment to their kombucha SCOBYs. Moreover, during the collective reflection workshop, participants identified the vitality and agency of microbes in kombucha fermentation practices.

The collective fermentation activity consisted of several activities. As the design probe activity involved a recipe writing activity based on personal experiences of participants, the collective reflection activity enabled participants to reflect on their practices collectively. Participants, knowing each other and the researcher before the activities, relied on already established personal ties for having an open and straightforward discussion. Moreover, we have conducted the activities in our native language, Turkish. Although the use of the native language enabled a smooth conversation, delving into human-microbe relationality was challenging due to the novelty of the theme for the participants. Therefore, I designed a design probe activity to expand the learnings beyond everyday level concepts to in situ interactions during fermentation (see Figure 9). The design probe activity involved a recipe writing activity and expanded the conversation from abstract human concepts to moments of material interaction with microbes. Therefore, recipe writing enabled detecting and revealing the memorable moments that participants interact with the kombucha SCOBY. Since participants recorded the moments of interaction with their SCOBYs, we were able to discuss their memories in the collective reflection workshop. Written recipes connected participants with their

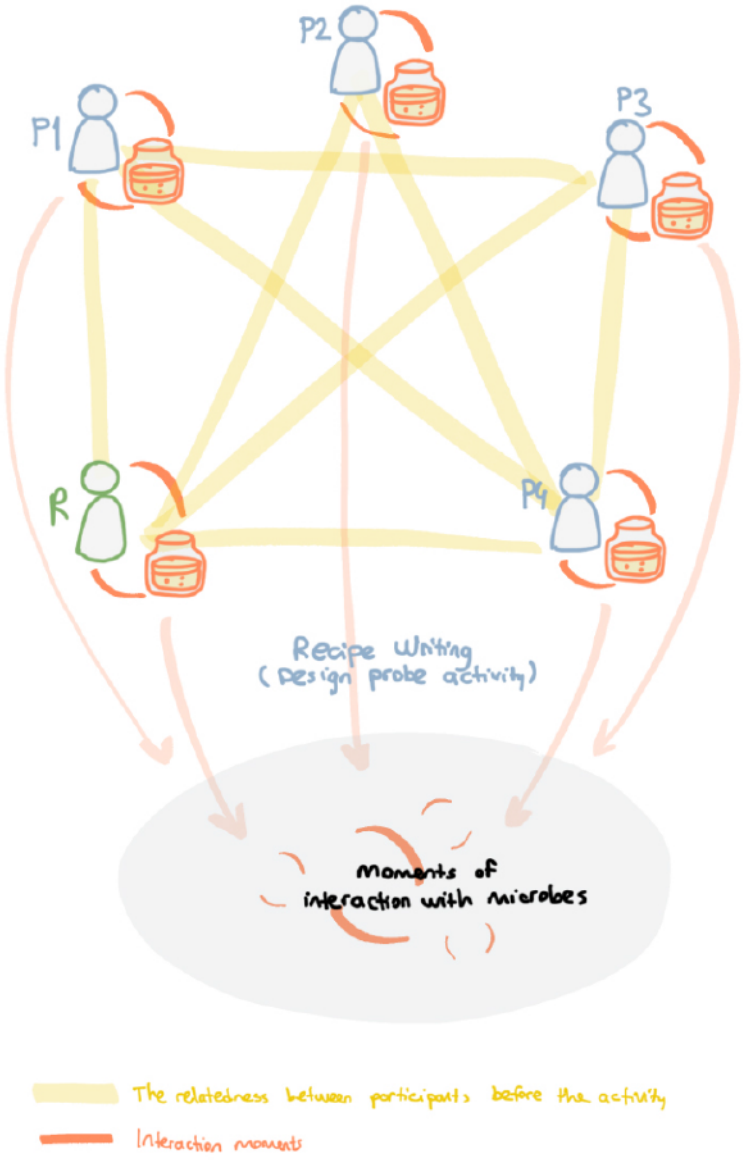


Figure 9. Recipe writing activity for collecting the memories of interaction

memories of in situ interactions and memories of caring for kombucha. The collective reflection activity delved into these memories of interactions and explored how participants cared for the SCOBY during these memories. In this way, the activity design succeeded in ***providing a space to recognize relationality*** with microbes in kombucha fermentation practices. Since the group interaction enabled elaboration on ideas, memories, reflections, and feelings, the activity opened up a space for recognizing relationality with microbes in kombucha fermentation practices.

The design of collective kombucha

fermentation activity revealed ***the agency of relations*** in the empirical research process. While the relations with the memories of interaction helped the memory during collective reflection activity, the relations between participants and researcher contributed to creating a safe space for free expression of ideas and emotions. Moreover, the relations between participants and their SCOBYs provided a significant part of the content of the research. Although the relations between participants and the researcher were on online tools, the reflection activity bonded our experiences together thanks to sharing reflections. Furthermore, revealing the interconnectedness with microbial bodies was unusual activity. Therefore, the activity resulted in some intimacy in which we discussed the relations with microbial bodies through a language of interconnectedness rather than instrumentalization. This language was established thanks to the selection of themes during the collective reflection activity, which emerged from attunement to the needs of microbes. Moreover, collectivity enabled participants to explore the relationality with microbes together by increasing their capabilities of sense-making.

Participants revealed the ***feeling of interconnectedness*** through the reflections on caring activities. As participants created the right environment for the survival and growth of the microbial bodies, they attuned themselves to the needs of kombucha SCOBY. The actions of preparing a clean jar, providing starter tea at the right temperature, keeping the fermentation jar in the dark places, and keeping the SCOBY in acidic tea after fermentation revealed the activities of care supplemented by attuning the senses and the embodied knowledge to the fermentation processes (see Section 5.1.3). Therefore, the participants recognized that their actions were oriented by providing benefits to the kombucha SCOBY.

Furthermore, participants also tried to improve the benefits they provide from kombucha SCOBY. Participants modified the recipes and adjusted the fermentation time according to their preferences of sweetness and sourness. Ensuring the health of the SCOBY seems to be originated from instrumental values, but beyond instrumental value, participants manifested the feeling of attachment and interconnectedness with the SCOBY in recipe notes and collective reflection activity. The mix of instrumental values and intrinsic values pointed out relational values (see Section 5.1.3).

For relational approaches (see Section 3.3), interconnectedness informs ***blurring the categorizations of entities***, revealing the distributed agency in the social-ecological realm. As participants attuned themselves to microbial bodies through their senses and embodied knowledge, the human participants shared the agency with the microbes in the fermentation process. Therefore, in fermentation practices, the agency was shared among humans and nonhumans, and it was manifested in several ways:

- Participants extended the fermentation duration according to the taste of fermented tea and the thickness of SCOBY.

- P1 mentioned that she felt an urge to share kombucha SCOBY because it grows and replicates itself. As the kombucha SCOBY makes people share themselves, people increased the chance of providing kombucha SCOBY in the future by sharing them with other people. After spoilage, P1 was able to find another SCOBY from P4. However, P2 had recently moved to another country. Thus she lost the connection with her relative who provided kombucha SCOBY.

- While P4 shared her SCOBY with other participants in the past, she also shared her recipe and knowledge emerging from her experiences. During the reflection workshop, other participants realized that their understanding of the wellbeing of kombucha SCOBY was mainly based on P4's instructions. For example, P4 instructed them to close the jar's lid with a cloth when putting it into the fridge. However, a recent experience of P2 revealed that kombucha SCOBY still survives if the jar is fully closed. This revealed P4 shared the knowledge of fermentation as well as the kombucha SCOBY. This incident revealed an example of a material-knowledge connection informing the agency of relations in creating the knowledge of kombucha fermentation.

Thanks to relational approaches emerging from the literature review, I could define and conceptualize the interconnectedness and the agency of relations in kombucha fermentation practices as a finding. These concepts informed the agency of nonhumans in kombucha fermentation practices and ***blurred conceptual categorization of human and nonhuman***. Emphasizing the blurry boundaries of the human and decentering the human enabled a relational way of theorizing for sustainability, in which human needs are entangled within human-nonhuman entanglement.

Beyond blurring categorizations, the practice of kombucha fermentation also enabled blurring the categorizations of consumption and production. In kombucha fermentation practices, neither human and nonhuman plays the single role of producer or consumer. As human bodies provide the sugar and environment for the microbial bodies, microbial bodies provide a sour and enjoyable drink. ***The blurred categorization of producer and consumer*** is also evident within the microbial community, in which yeast and acetic acid bacteria contribute to their environment by sustaining their symbiotic relations. Humans aim to nurture the microbial community as long as possible for the subsequent fermentation, and this relation of sustainment can last from months to years. Therefore, I defined kombucha ***fermentation as an activity of sustainment*** supported by the relationality of human and nonhuman bodies. The proximity of agents in kombucha fermentation made the practice more resilient since attunement was possible thanks to the proximity of bodies, embodiment, and sensory experience.

Since I approached the kombucha fermentation activities as an activity of sustainment, I conceptualized the learnings on kombucha fermentation practice as a stage to reflect on sustainability. The literature search on kombucha fermentation and empirical research informed interconnected relations of wellbeing (see Section 4 and Section 5). Microbial ecology informs that ecologies rely on microbes to maintain the biochemical processes of living systems (Madigan et al., 2017, p. 42). Within this context, the ***interconnected wellbeing*** within kombucha fermentation practices informs the multispecies wellbeing discussions in sustainability (see Section 3.2). The concept of interconnected wellbeing leads to the need for the understanding of "multispecies sustainability" (Rupprecht et al., 2020). Due to the agency of relations in sustaining vitality in social-ecological entanglements, the concept of wellbeing needs to expand from the human level to the social-ecological level.

Furthermore, recognizing relationality with nonhumans links to the concept of recognition in environmental justice (Schlosberg, 2020). As this thesis reveals,

recognition of nonhumans emerges from the normative aim of recognizing the interconnected wellbeing with nonhumans through a web of relations involving practices, proximity, space, and meanings. Consequently, ***recognition can be practiced*** by informing, emphasizing, and building the relations that have been dismissed before. Within the context of my research, these relations were about kombucha fermentation, involving the human-microbe interdependence, blurry conceptual categorizations, the agency of relations, and the feeling of interconnectedness. However, further research can focus on other contexts by reconnecting the disconnected bodies within social-ecological entanglements. The boundaries of human concepts and language might be challenging for recognition. Still, design can provide ***material-semiotic tools*** for expanding the practice of recognition beyond human concepts in novel ways. In this way, design for sustainability adopts the role of creating tools for recognition, and consequently, reconnecting bodies through novel ways of relating.

Furthermore, beyond human-nonhuman interconnectedness, the same ideas can be reflected onto human-human relations, in which human inequalities can be approached with the idea of interconnectedness contributing to an intersectional analysis of significant disparities of race, class, and gender. This kind of intersectional analysis can challenge the hegemonic forces of patriarchy, capitalistic values, neocolonial distribution of risks and benefits. For example, Bookchin (2007, p. 20) argues that these forces put pressure on both people and ecologies. The idea of interconnectedness also emerges from intersectional theories that connect social, political, and environmental issues (Walsh et al., 2020, p.79) to reveal the relations between different types of inequalities that deplete the potentials of a decent life.

6.2. Attuning to the other in human-nonhuman relations

The sensory experience and embodied knowledge informed the participants through the kombucha fermentation practices. Interviews with participants and their recipe notes involved elements of sensory experience and embodied knowledge. These elements enabled the participant to attune their actions to the needs of kombucha SCOBY. While sensory experiences happened simultaneously during kombucha fermentation, the embodied knowledge helped them to develop their practices over time. Attuning to the needs of kombucha enabled participants to care for their SCOBY and ensure the desired taste.

The ***sensory experiences*** in kombucha fermentation practices involve various elements related to the human senses. For example, the thickness of kombucha SCOBY informs participants about the progress of the fermentation process and the wellbeing of the microbial community. The brewers frequently check their SCOBY to avoid spoilage. Moreover, the scent of kombucha provides similar knowledge about the progress of fermentation. The sense of taste offers knowledge about the acidity of the fermented tea and enables fermenters to tailor the fermentation time according to the desired taste. As the senses connected the human bodies to nonhuman bodies, the fermentation practice became more resilient thanks to attunement and attentiveness.

The ***embodied knowledge*** develops over time by learning the responses of kombucha SCOBY to the actions during kombucha fermentation. Although brewers start fermentation by relying on informal knowledge transfer from other people or written sources, they develop and modify

their methods and recipes based on their experiences during kombucha fermentation practices. The embodied knowledge emerges from the close relationship between human bodies and nonhumans but embodied knowledge is not easy to express with the mundane language concepts. Within the empirical research, the customized skills of participants revealed their embodied knowledge about kombucha fermentation. These skills involve personalized tricks and methods such as replacing a tool, modifying an ingredient, or gestures and tricks for improvisation. Since the brewers understood the reason behind the fermentation phases, they felt the inherent freedom to tailor their gestures to existing environments, tools, and conditions.

The sensory experience and embodied knowledge were possible thanks to the ***proximity*** of human and nonhuman bodies in the kombucha fermentation practices. Therefore, proximity is an essential condition for attunement. Furthermore, the embodied knowledge indicated the role of embracing different ways of knowing in the context of human-nonhuman entanglements. Since the recognition of nonhumans plays a crucial role in the context of "multispecies sustainability" (Rupprecht et al., 2020), proximity and diverse knowledges could enrich the ambitions that aim to include nonhumans into the processes of design. Proximity and attunement counters "the aesthetic disconnection" from industrial food chains (Fesmire, 2010, p. 184) and improves the capabilities of human participants in creating their own beverages.

An inquiry into the proximity and senses leads to another level of sensory experience emerging from kombucha fermentation practices. Unlike the industrial ways of producing and consuming, kombucha enables fermenters to modify the taste of kombucha according to their preferences. The kombucha brewer can adjust the sourness/sweetness balance, flavor, and base tea variety. Furthermore, the brewer feels the scent, touches to fermenting SCOBY, and sees the growth of the kombucha SCOBY during the production of the beverage. In this way, the kombucha fermentation practice ***enriches the sensory experience*** by providing stimulating scents and tastes for the brewer. Furthermore, the bodily activity of fermenting kombucha immerses the brewer into a corporeal interaction with the microbial community. Therefore, in comparison to bottled kombucha, the practice of kombucha fermentation becomes more satisfying for the mind and health.

6.3. Relational ethics for sustaining human-nonhuman relations

Relational ethics have been proposed as a third category alternative to intrinsic and instrumental values in environmental ethics literature (Stålhammar & Thorén 2019; Himes & Muraca, 2018; Chan et al., 2018). In the empirical research, I was attentive to relational ethics and how it might manifest itself within relations. In the recipe notes and collective reflection workshop, I observed that relational ethics acts as a category of value that develops over time. When participants had started the practice of kombucha fermentation, they expressed their interest in the instrumental value, which is the touted health benefits of kombucha beverage. However, over time, participants seemed to develop a new kind of ***attachment*** with their SCOBYs.

Emotional attachment to kombucha was apparent within the behaviors of taking care of SCOBYs, keeping them alive, and avoiding contaminating them despite having spare SCOBYs. Moreover, being able to observe the vitality of kombucha might have

changed the category of value of kombucha SCOBY from a material to a lively companion. For example, a participant (P1) kept the kombucha SCOBY alive for a long time even she was not drinking kombucha. Moreover, the idea of frying and eating kombucha disturbed P1 since it would be killing the kombucha SCOBY. The emotional attachment also manifested itself after P4 shared her SCOBY with P1. In recipe notes, P1 mentioned that she could not see the new SCOBY as her "own" SCOBY. I believe that the need for "ownership" implies the need for having time for attachment to the new SCOBY. Moreover, P4 was worried about a small mistake of using stevia despite having three more healthy SCOBYs. Other participants shared similar feelings about the kombucha SCOBY. Their journeys revealed that proximity and the vitality of SCOBY developed the ***relational ethics emerging from the interaction*** between humans and nonhuman bodies. Attachment to the kombucha SCOBY has lead to caring for the kombucha SCOBY in more attentive ways. Moreover, with the help of embodied knowledge and sensory experiences, the fermenters attuned themselves to the needs of kombucha SCOBY.

The relational ethics within kombucha fermentation practices can inform sustainability research in several ways:

- First, the relational values developed through human-nonhuman interaction can inform an alternative value framework that can supplement intrinsic values and instrumental values in environmental ethics (Himes&Muraca, 2018; Stålhammar & Thorén, 2019; Chan et al., 2018).

- Second, relational values grant value in place-bound interactions. For example, relational values can conceptualize how people develop an attachment to their environments (Himes&Muraca, 2018; Escobar, 2001, as cited in Agyeman et al., 2015, p. 12) and the reciprocal constitution of human and nonhumans bodies in social-ecological entanglements (West et al., 2020, p. 310).

- Third, relational values can inform the post-humanist approaches by providing a framework for resolving the challenge of attuning to the needs of nonhumans beyond human concepts and language. As human concepts cannot directly address nonhuman needs and wellbeing, my thesis framework aimed to move beyond human concepts by providing learnings with a material-semiotic tool that focuses on in situ memories and a collective reflection workshop.

Within my thesis, relational ethics emerged from embodiment, attachment, and sensory interactions. Although these are the outcome of the kombucha fermentation, this learning can inform other areas of sustainability research for exploring human-nonhuman relations in social-ecological entanglements.

The interaction mentioned above and the meanings in relational ethics were partly guided by human meanings about life and death. However, the kombucha practice and the microbial bodies inform revisiting the concept of death and life. For example, while participants kept the SCOBY alive, their intentions were not based on individual microbes but the community. Since SCOBY is seen as a living entity rather than individual bacteria bodies, the concepts of 'death' and 'living' refer to the microbial community rather than individual bacterias. Referring to the meaning of life to the microbial community links to the fact that the human perception attributes the property of life to the SCOBY. However, an advanced inquiry might inform the need to

reconfigure concepts like death, life, destruction, and exploitation. Although this discussion is far beyond the scope of my thesis, I believe that microbial relations might blur the categories of life and death in further research.

6.4. Grounding knowledge and values within relations

According to feminist standpoint theory, knowledge is situated in social relations and practices (see Section 3.3). As ***situated knowledge*** undermines the objective knowledge that sciences are based on, power relations also come into play in the construction of knowledge. Therefore, the epistemologies for relationality acknowledge the role of positionality and power in constructing knowledge. Furthermore, relational approaches are interested in the connections between knowledge and the material world. For example, during the collective kombucha fermentation activity, participants recognized that they have taken for granted the knowledge they learned from the person who provided SCOBY (see Section 5.1.3). Beyond being an example for the situatedness of knowledge, this incident also posits knowledge and materiality embedded in each other (Barad, 2007). Another example of the situated knowledge is about the pathogenic framing of microbes in scientific knowledge. As Salla Sariola mentioned (see Section 4.4), the pathogenic framing of microbes emerged from the historical context of discovering microbes. Since microbes were defined in relation to diseases, human knowledge reduced them to pathogenic entities that need to be eliminated from human environments. However, recent research reveals the misguided framing of microorganisms. Microbiome research indicates that human wellbeing is dependent on microbial diversity in the body (Cullen et al., 2020, p. 3). Moreover, the antibiotic approach to life results in a greater risk for the wellbeing of people, such as antibiotic resistance (Douglas, 2018) and dysbiosis (Prescott et al., 2018, p. 3).

Situated knowledge informs ***diverse ways of knowing*** (see Section 3.3). Knowledge can be constructed through scientific, traditional, or embodied ways of knowing. For example, participants started the practice of kombucha fermentation due to health concerns and touted health benefits. Although health concerns are generally framed within medical science, participants' entry into a healthy practice was initiated by their social sphere. Moreover, the empirical research also pointed out the intuitive and affectual ways of knowing. For example, one of the participants mentioned that fermenting kombucha felt like a self-care activity. Although scientific research informed the touted health benefits of kombucha, the health benefits of kombucha reached out to participants through other ways of knowing.

With this background, my thesis also explored the ways of ***contextualizing knowledge*** based on the kombucha fermentation practices. Grounding knowledge and ethics in relations were necessary for my research because humans and nonhumans do not share abstract concepts. This inquiry has already been supported by the aforementioned embodied knowledge, relational ethics, and the sensory experience. These concepts revealed the importance of proximity in relations influencing experiences, ethics, attachment, and knowledge. Furthermore, 'aesthetic disconnection' in current unsustainable systems reveals the need for attachment for building sustainable relations with nonhumans. Overall, despite far-reaching implications in systems, the proximity to the context can ground knowledge and values within relations.

Furthermore, situated knowledge informs that knowledge relies on its context and recognizing diverse ways of knowing ends up ***rejecting epistemological hierarchies***. Therefore, the human faculties for knowing the interactions in systems require acknowledgment of positions and the limits of horizons. For example, I argue, antibiotic resistance has been a result of exceeding the human horizon in understanding unintended consequences of bacteria evolution. The recent research on microbiology informs new groundbreaking insights, but their implications are far-reaching and difficult to grasp. The problem of human horizon raises whether human understanding can grasp the human impact on ecosystems. Therefore, sustainability knowledge needs frameworks to acknowledge the human horizon and the inability to control vital processes within social-ecological entanglements as kombucha fermentation practices inform the agency of nonhumans, the managerial approaches defining the nonhuman environment as passive need to be challenged. "Relational thinking provides resources to re-work and re-think conventional research practices and residual, often difficult-to-detect modernist assumptions" (West et al., 2021, p. 113). With this background, the relational approaches enabled me to explore kombucha fermentation practices to reflect on 'difficult to detect' assumptions of modernist ways of relating nonhumans.

Discussion

This section aims to interpret the findings for further research. Therefore, in this section, I discuss the relational approaches and relations with nonhumans in the context of design for sustainability. First, I will reflect on the research process and design discipline. Second, I posit the concept of designing relations for sustainability. Third, I contrast the kombucha fermentation practice with the industrial mindset. Fourth, I explain how the capabilities approach supported relations with nonhumans. Then, I argue for reconstructing tools and concepts for relationality. Finally, I discuss on the need to vitalize aesthetics and concepts.

7. Discussions

As an industrial designer studying sustainability, I had the privilege to reflect on disciplinary conventions of knowledge and sense-making by transgressing the boundaries to explore new territories (Gaver, 2016, p. 196). The first thing I noticed was my limited knowledge in microbiology, which I believe, caused by the lack of "life" in design and sustainability. I found disciplinary knowledge limited when exploring multispecies entanglement on the everyday level. For example, design and sustainability did not grant agency to nonhumans while taking natural resources for granted. Moreover, the dependencies on industrial distribution networks became more apparent when studying the place-bound practice of kombucha fermentation. Although fermentation processes are place-bound, kombucha fermentation still needs sugar, tea, energy, and water from the industrial infrastructures. With the dominant logic of industrial networks in sustainability and design, exploring an activity in which producers and consumers are entangled has been challenging. These limitations pointed out that ignoring or obscuring particular relations is an implicit consequence of disciplinary conventions. When the capitalistic mindset is a background in knowledge production (Kallio & Houtbeckers, 2020, pp. 2-3), following alternative imaginations become challenging but motivating. In kombucha fermentation practices, what motivates imagination has been the alternative way of relating to nonhumans. Moreover, my background in activism and my interest in contemporary arts and critical theories guided my intuition to radical ends within sustainability research. Therefore, I kept skepticism about modernist narrations of design and sustainability, which are based on technological fixes, progress, human rationality, and economic growth.

7.1. Reflections on the design and research

Relational approaches inform the agency of relations that constitute the entities. Let design be an entity; the relations of design with its context would have agency. Since design has primarily aimed to provide goods and services for companies (Held 2016, p. 192), its disciplinary conventions are based on dismissing social-ecological relations and inequalities systematically (Boehnert, 2014, p. 2). For example, human-centered design dismisses the dependency on nonhumans and, unwittingly, operates for extracting value from ecology (Forlano, 2017). Moreover, the lack of established frameworks to study nonhumans inform that disciplinary conventions are relationally constructed rather than objective knowledge. These reveal that dismissing the relations within social-ecological entanglements has been a part of disciplinary conventions of design. As these conventions also defined the act of designing, my inquiry explored an alternative way of relating nonhumans as well as trying to understand the relations of design with its contexts. This insight leads me to reflect on the act of designing beyond systems, artifacts, and services, which is the design of relations.

Kombucha fermentation practice can be defined as a prosumer activity in which production and consumption are entangled in close proximity (Kohtala, 2015, p. 657). The proximity of production to consumption is foundationally different from the industrial logic; therefore, kombucha fermentation practice does not correspond to the prevailing categories of design. For example, the participants did not fit in the user category since they are producers at the same time. Human-microbe relations would not be included in the participatory design because the participatory design initially distances "the

user" and puts it back to the design process. Design co-creation is not sufficient in multispecies relations and does not involve material production. The incapability of design concepts reveals the lack of frameworks to study lively interactions with nonhumans. Furthermore, the limitations of design also gave some clues about the extractive manner of design to the material world and its embeddedness into industrial logic. Therefore, I relied on general terms in fermentation and everyday life to conceptualize kombucha fermentation.

Through the empirical research, my relations with others had the agency on defining the content and approach of my thesis. An inch of kombucha SCOBY, I provided from a food workshop three years ago, still lives with the research participants and me. My experience of kombucha fermentation practice enabled me to reflect on the topic of human-nonhuman relations. As my partner shared the kombucha SCOBY with the participants of the empirical research, I could involve participants that we had relations with. I believe that having existing relations with participants made the communication smoother and widened the scope of research insights. Moreover, my relations with my advisor and supervisor of the thesis guided the research, opened up a space for creativity but kept the research relevant for design for sustainability. Furthermore, the experiences from my past and theories from my background enabled exploring the research questions from different lenses. My digital diaries, the literature readings, and the mindmaps also had agency. Through the research, I felt the tension between institutionalized disciplinary boundaries and the critical perspectives from my background. Due to the lack of established frameworks to study human-nonhuman entanglements, I needed to look at design and sustainability from the outside.

7.2. Designing relations for sustainability

An implication of relational approaches for design would be proposing a practice of the design of relations. Implicitly or explicitly, design has already been intervening in relations between humans, nonhumans, artifacts, and systems. The design-in-service-mode of neoliberalism (Julier & Kimbell, 2019, p.20) acts as a goal-oriented discipline guided by the industrial-capitalist model of value extraction from social-ecological entanglements (Boehnert, 2014). The values that guided Design has been naturalized (Berglund & Julier, 2020) or unattested because design is responsive to its context (Julier, 2013, p. 219). The industrial model of value extraction is assured by externalizing the exploitation of nonhumans (Boehnert, 2014, p. 11). Therefore, the values that design adopts come into prominence when reconfiguring the relations in social-ecological entanglements.

Furthermore, design has been dematerializing (Frascara, 2003) in post-industrial societies, which externalize the production of industrial goods and shift to service-based economies. Although dematerialization means distancing design from materiality, Schlosberg insists that sustainability approaches need to be based on materiality (Schlosberg, 2020). The dematerialization of design in neoliberal conditions highlights the risks of externalization of responsibilities. Moreover, design and sustainability conversations focus on the narrative of "problems to solve" through expert interventions (Ehrenfeld, 2008, pp. 4-5). On the contrary, Ehrenfeld (2008) proposes a positive pathway of flourishing livelihoods for sustainable design. Transitions for sustainability could emerge from the materiality of everyday practices (Manzini, 2019, pp. 70-75).

Within this background, the design of

relations might mean reconfiguring the relations that constitute the social-ecological entanglements, rather than limiting the capabilities of design in managerial ambitions decoupled from the vitality of materiality. Beyond problem-solution orientation within 'design-in-service mode,' 'flourishing' livelihoods by designing the relations rooted in materiality and everyday life would be one of the pathways for design for sustainability. In this way, the design of relations has the potential to ground values within relations with the nonhuman environments by contextualizing knowledge, ethics, and experiences in everyday materiality.

7.3. Kombucha fermentation practice is against the industrial logic

The themes of kombucha fermentation and relationality have made it possible to diverge from the pervasive industrial-capitalist mindset rooted in the disciplinary conventions of design. Since my personal experience of the design profession emerged from industrial settings in which sustainability is only mentioned as the ambition to save energy and improve efficiency, I aimed to distance my theories from narrow-sighted technical fixes. Moreover, in this thesis, I cut my relations with existing design concepts, such as "user," "product," and "user research." Tools and concepts have agency of the values and context they are created for. Using the design terms would lead to being embedded in an extractive and instrumentalizing way of theorizing nonhuman relations. On the contrary, situating my conceptual tools distant from design enabled exploring an alternative way of relating to kombucha SCOBY.

With the help of relational approaches and creative narratives that conceptualize multispecies entanglement (see Hey, 2019b; Katz, 2012; Fournier, 2020), I navigated the human-nonhuman entanglements through my thesis. As kombucha fermentation is a multispecies activity, it reconnects the bodies in the close proximity of consumption and production. On the contrary, industrial production is disconnected from the consumers and distances them systematically and intentionally. Beyond concealing the exploitation of nonhumans with 'aesthetic disconnection' (see Section 4.4), supply chains render consumers passive and lacking capabilities of "ethically informed action" (Schlosberg, 2020). On the other hand, humans and microbes coexist throughout kombucha fermentation practices, and proximity leads to a sustainable relationship based on its emerging relational ethics. While the brewer enjoys being able to customize the taste of kombucha, replication of SCOBY encourages sharing behavior. The activity of sharing SCOBY does not follow the capitalistic logic of buying or selling a product. The activity of sharing has a solidaristic side because people secure their future supply of kombucha SCOBY by sharing it with their social sphere. In kombucha fermentation, sharing encourages sustainable practice, unlike the industrial logic providing sustainable products through purchasing decisions of individuals. Since economic privileges also shape purchasing decisions, a sustainable lifestyle becomes a commodity within industrial logic.

Another inspiring feature of kombucha fermentation is its openness and forgiveness. In the presence of SCOBY, kombucha fermentation is possible by using simple kitchen tools. While jars, towels, and elastic bands make up the fermentation vessel, tea preparation tools, tea, and sugar are used to prepare starter tea. In addition, kombucha is an enduring microbial community that can forgive small mistakes. For example, some

participants needed to replace some of the ingredients and tools. They were able to modify the ingredients and fix small mistakes thanks to the durability of kombucha.

7.4. Knowing and caring depends on capabilities

In kombucha fermentation practices, sensory experiences and embodied knowledge enable humans to attune themselves to the need of nonhumans (see Section 6.2). Proximity enabled attachment and informed the emergence of relational ethics (see Section 6.3). Therefore human brewers recognized relationality with nonhumans and ensured the well-being of kombucha microbes. Relational ethics emerges from attentiveness to nonhumans and the capabilities of brewers to take care of the microbes. Grounding knowledge and ethics in relations improved the capabilities of subjects to know and relate to nonhumans. As capabilities are informed by the distributed agency, sensory experiences, and embodied knowledge, the proximity of relating nonhumans has been the fundamental condition for recognizing relationality. Furthermore, the characteristics of the microbes supported the multispecies relations. Kombucha fermentation is flexible, durable, and forgiving, meaning that it is open to changes and easy to maintain for the brewer. In this way, kombucha is an open and forgiving activity that allows caring for and building a sustainable multispecies relationship. The kombucha practice is contrary to market logic, and this makes kombucha shareable rather than captivating it. Since capabilities provide materialistic explanations for ethical actions, it can dismantle virtue ethics relying on essentialist abstractions (Mandalaki & Fotaki, 2020, p. 750). Although the insights from empirical research defined capability through the proximity of human and nonhuman bodies, this approach can surpass individual domains and inform collective capabilities (Manzini, 2019, p. 48).

7.5. Reconstructing tools and concepts

As relational approaches pointed out, concepts need to be reconfigured for conceptualizing relationality (Emirbayer, 1997). I designed the collective fermentation activity within the empirical research to reconfigure the human-nonhuman concepts for recognizing alternative ways of relating with nonhuman bodies. The normative aim of reconfiguring the conceptual boundaries of humans required recognizing alternative ways of relating to nonhumans. Reconfiguring concepts through abstract arguments would be possible. However, I wanted to connect the meanings with real moments through a recipe writing activity and collective reflection activity (see Section 5.2 and Section 5.3). The concept of 'material-semiotic' from feminist research inspired me to delve into connections among meanings and materiality (see Section 3.1 & Section 6.1).

As recipe writing connected us to the moments of interaction with microbes, the collective reflection workshop focused on how participants attuned themselves to the needs of nonhumans. Therefore, the agency of microbes was recognized thanks to the material-semiotic reconfiguration enabled by designed methods. This approach was helpful in retrieving the in situ interactions during kombucha fermentation practices. Rather than relying on abstractions, this tool enabled participants to reflect on moments of interaction with nonhumans. Although the framework of the thesis was limited to kombucha fermentation, this approach can inspire design for sustainability in terms of

reconfiguring the conceptual landscape that regulates human-nonhuman relations. According to my interpretations and research experience, it is possible to situate and reconnect meanings, moments, and bodies with the help of design tools. As relational theories horizontalized meanings with materiality, the material-semiotic tool became more vivid and possible. These kinds of tools can inform the design of the relations for the social-ecological entanglements (see Section 7.2.).

Furthermore, my research process was informed by mindmaps that aimed to note my learnings from literature and empirical research. In these maps, I connected entities, beliefs, processes, and domains without strict categorizations (see Appendix G). As relational approaches informed meaning and material entanglements, I horizontalized different categories in my mindmaps. This approach deviates from systems approaches that rely on interacting entities and categories. However, systems thinking relies on essentialist categorizations that limit critical inquiry (see Section 3.3). On the contrary, by blurring categories of knowledge and entities, a relational way of mapping the reality would enable blurring and reconfiguring categories, exploring social-ecological entanglements. Although I did not try to develop a "relational way" of mapping my ideas, the topics of microbes and relational theories necessitated horizontalizing concepts and entities. However, a further elaboration of 'relational mapping' could also inform the situatedness of the researcher.

7.6. Vitalizing aesthetics and concepts

The normative aim of blurring the boundaries of humans also manifested itself on other levels related to meanings and aesthetics. As the domain that connects human bodies to nonhuman bodies is vital and contingent, other domains of meanings and knowledge are also relevant. Beyond ethics, aesthetics of relations need reconsideration. For example, exploitation has been a critical theme that is contested in sustainability. Although exploitation has negative meanings and its theorization in sustainability is missing (Feola, 2019), I think the problems with this concept are much more profound. Within microbial relations, the borders of exploitation, eating, and symbiosis are blurry. Therefore, exploitation is an inherent part of the microbial landscape. Another concept, which can be questioned in microbial relations is death. Although death is taboo in many cultures, the death of a microbe is based on contingent encounters. These kinds of taboos around vitalist concepts reveal the need to reconfigure basic concepts about life and death beyond human understanding.

As aesthetic values are related to conceptual boundaries and collective meanings, they can also be reconfigured by new relations. For example, P2 mentioned that people feel disgusted due to the look and texture of kombucha SCOBY. However, as long as they experience the taste or learn the benefits of kombucha, the feeling of disgust disappears. This incident reveals that aesthetic values also regulate the human-nonhuman divide, and they can be reconfigured through experiences or new meanings. Vitalizing the aesthetical meanings might be possible by challenging modernity aesthetics, which is based on cleanliness and elimination of nonhuman others

Conclusion

In the conclusion section, I review the main goals and learnings from my thesis process and reflect on the research process. Finally, I review my insights on design, sustainability, and add final remarks about alternative ways of relating nonhumans.

8. Conclusion

Informed by three years of personal experience of fermented beverages and food, the thesis helped me reflect on the theoretical discussions related to design for sustainability. For example, relationality revealed that materiality and meanings are entangled. Therefore, my conceptual ambition to emphasize reciprocity in relationships can materialize alternative ways of relating to nonhumans in everyday situations. Therefore, my thesis aimed to enable recognizing the relationality with nonhuman entities during kombucha fermentation practices. For this, I explored the ways humans attune to nonhumans in kombucha fermentation, and relational ethics emerging from human-nonhuman relations, and the ways to ground knowledge and values within relations. I believe that the recognition of nonhumans could have tangible impacts on the everyday level. Therefore, I adopted an approach emphasizing interconnectedness between humans and nonhumans rather than adopting an instrumentalizing approach to nonhumans. As this approach leads to philosophical inquiries into human-nonhuman relationships beyond the disciplinary conventions of design and sustainability, my research approach aimed to enrich the discussions in sustainability with inspirations from other areas of knowledge. In the context of my thesis, this knowledge resided in the connections among relational theories, kombucha fermentation practices, and the nonhuman realm situated beyond the industrial-capitalistic values of established frameworks. Overall, the thesis acted on the ground of exploring and importing learnings and inspirations from alternative ways of relating to nonhumans beyond established boundaries of concepts, knowledge, values, and feelings.

8.1. Overviewing the recognition of relationality with nonhumans

The literature research informed that exploring relations can enable transcending the conceptual boundaries between humans and nonhumans. Since relations constitute entities, relationality approves dismantling substantialist assumptions. As substantialist approaches are based on unchanging essences, they solidify conceptual boundaries between humans and nonhumans. However, microorganisms blur the boundaries of human by revealing the dependence of human health and immunity on the microbiome. On the contrary, relationality emphasizes the interconnectedness among humans and nonhumans, and antibiotic resistance indicates the need for understanding the interconnectedness of wellbeing in broader contexts. Yet, relational approaches defined the recognition of relationality and interconnectedness as emergent conditions depending on embeddedness. For example, participants relied on embodied knowledge and sensory experiences for attuning themselves to the needs of nonhumans. Therefore, relational ethics required contextualizing knowledge and acknowledging diverse ways of knowing and situatedness.

During empirical research, the proximity of humans to nonhumans led to relational ethics beyond human concepts. The emergence of relational ethics negated the 'aesthetic disconnection' from food production that justifies the exploitation of nonhumans in extractive systems. Therefore, relational approaches emphasize grounding values and knowledge in relations rather than universalizing values based on essentialist abstractions and top-down management schemes. As antibiotic resistance indicated, rendering microbes as controllable and dismissing the complexity of evolutionary relations beyond the human horizon lead to a global health problem.

Therefore, microbial relations and relational approaches inform that vitality of social-ecological entanglements does not fit in human concepts and essentialist abstractions. Thus, conceptual tools need to acknowledge the vitality of human-nonhuman relations.

The empirical research design provided participants a space for delving into their relations with microbes, therefore, resulting in the understanding of the agency of relations and the feeling of interconnectedness. Since participants recorded their moments of interaction with microbes, we could reflect on these memories collectively. The recipe writing activity as a design probe was the most prominent part of empirical research, which revealed the agency of the relations between memories and subjects in a research process. Although I have designed the empirical research as a remote activity, recipe writing activity (design probe) captured the connection between memories and meanings. The findings revealed sensory experiences and embodied knowledge which informed attunement to microbes. The attunement to nonhumans enabled conceptualizing kombucha fermentation as an activity of sustainment supported by relational ethics.

As relational approaches defined humans and nonhumans as reciprocally constituted, the kombucha fermentation practices and relational approaches enabled blurring the boundaries of humans and nonhumans. The blurry boundaries informed the symbiotic relationship and helped me to define kombucha fermentation as a multispecies activity of sustainment. As the characteristics of the microbial community made kombucha durable, human-nonhuman relations became more resilient. Moreover, the openness and durability of the microbial community rendered the kombucha fermentation practice durable. Kombucha fermentation does not require special tools, and it is open to recipe variations. Therefore it is a flexible and forgiving activity enabling coexistence. Caring is a hands-on experience thanks to the scale and proximity of fermentation. In kombucha fermentation, the knowledge of the participants was supported by their relations with bacteria, improving their attentiveness and embodied knowledge to care. Proximity, openness, and durability provided capabilities to human brewers to take care of their SCOBY.

I approached kombucha fermentation as an activity of sustainment to develop learnings from relationality and kombucha fermentation. Reflecting on these learnings on sustainability informed several insights about industrial ways of living and producing ethics and relations with nonhuman entities. Situated knowledge informed the need for incorporating diverse knowledges for sustainability research. Therefore sustainability knowledge can be grounded on everyday relations rather than managerial approaches relying on obscure value systems guided by representations of power. For this, it is necessary to integrate different types of knowledge within relations. Contextualization can develop an alternative framework for ethics that relies on material interaction rather than abstract values. Therefore, sustainability should seek to enhance people's capabilities to care for their livelihoods by recreating them. Attuning to socio-ecological entanglements and the interconnected wellbeing of humans and nonhuman can provide a sustainable future. Against the industrial mindset that disconnects human bodies from creating their livelihoods physically, culturally, and emotionally, relationality offers enriching daily life by weaving sustainable relations with nonhumans.

Although my thesis stems from my personal experiences, it has provided rich information on human-nonhuman relationships thanks

to the theoretical approach of relationality. Design and sustainability act on a problem-solution mindset directed towards the prevailing industrial systems. Nevertheless, while focusing on industrial settings, the values that reproduce unsustainable practices remain unattested. However, industrial logic adopts an extractive approach to social-ecological entanglements. Therefore, sustainable human-nonhuman relations should deviate from the industrial mindset and explore alternative ways of relating to others. Since sustainability necessitates recognizing relationality with nonhumans and ensuring multispecies wellbeing, adopting an extractive system of values to life dismisses the possibilities of interconnected wellbeing. Therefore, it is necessary to recognize and configure alternative ways of relating nonhuman bodies beyond industrial logic. Alternative ways of relating nonhumans necessitate reconsidering the agency of relations and materiality in providing people capabilities to create and care for their livelihoods.

8.2. Limitations

Since the research aimed to integrate theoretical and empirical findings from various domains of knowledge, such as everyday life practices, microbiology, relational philosophy, sustainability, and design, it was challenging for me to validate the connections among these disciplines. Although my immersion into these topics was limited, the thesis advisor, supervisor, and peers' guidance helped me reflect on complex and dense issues. Despite the prevalence of existing literature on multispecies studies, the experience of blurring reified conceptual divides between humans and nonhumans has been a challenging and unfinished task. The most significant limitation was the language that dissected the social-ecological entanglements to distribute the agency to only human subjects. I needed to operate within and dismantle the meaning system that created conceptual between humans and nonhumans. Furthermore, the lack of tools and concepts for studying human-nonhuman relations in design for sustainability challenged exploring the ways to recognize human-nonhuman relations in kombucha fermentation practices. The

8.3. Suggestions for Future Research

Blurring the epistemological categories and focusing on the agency of relations provided exciting and powerful tools and concepts for the context of design for sustainability. The agency of relations can enable moving beyond essentialist notions in systems theories. Moreover, the connections between entities, meanings, systems, and values allow bridging relations across interconnected domains of social-ecological entanglements. This kind of exploration, I believe, enables sustainability to grasp complex connections across domains and provide critical reflections on existing systems. Further research can explore the following areas of inquiry.

1. How are disciplinary conventions of design for sustainability shaped through relations with contexts and broader structures? What kind of relations had formed these conventions?

2. What kind of relations are systematically dismissed by the prevailing concepts and tools within design for sustainability?

3. How prevailing industrial networks configure or obscure human-nonhuman relationality within social-ecological entanglements?

4. What kind of human-nonhuman

relations are flourishing livelihoods in social-ecological entanglements? How can design for sustainability learn from these symbiotic relationships?

5. What kind of tools and concepts could enable mapping relationality in social-ecological entanglements?

Reference List

Agyeman, J. (2016). Sustainability. In J. Adamson, D. N. Pellow, & W. A. Gleason, Keywords for Environmental Studies. NYU Press.

Agyeman, J., Schlosberg, D., Craven, L., & Matthews, C. (2015). Trends and Directions in Environmental Justice: From Inequity to Everyday Life, Community, and Just Sustainabilities. Annual Review of Environment and Resources, 41(1), 1–20. https://doi.org/10.1146/annurev-environ-110615-090052

Barad, K. (2003). Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. Signs: Journal of Women in Culture and Society, 28(3), 801–831. https://doi.org/10.1086/345321

Barad, K. (2007). Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning. Duke University Press. https://www.jstor.org/stable/j.ctv12101zq

Bennett, J. (2010). Edible Matter. In Vibrant Matter: A Political Ecology of Things (pp. 133–145). https://read.dukeupress.edu/books/book/1346/chapter/165596/Edible-Matter

Berglund, E., & Julier, G. (2020). Growth in WEIRD Helsinki: Countering Dominant Urban Politics and its "Green" Pretentions. Sociální Studia / Social Studies, 17(1), 13–31. https://doi.org/10.5817/SOC2020-1-13

Blaser, M., & Escobar, A. (2016). Political Ecology. In J. Adamson, D. N. Pellow, & W. A. Gleason, Keywords for Environmental Studies. NYU Press.

Bloomfield, S. F., Rook, G. A., Scott, E. A., Shanahan, F., Stanwell-Smith, R., & Turner, P. (2016). Time to abandon the hygiene hypothesis: New perspectives on allergic disease, the human microbiome, infectious disease prevention and the role of targeted hygiene. Perspectives in Public Health, 136(4), 213–224. https://doi.org/10.1177/1757913916650225

Boehnert, J. (2014). Design vs. The Design Industry. Design Philosophy Papers, 12(2), 119–136. https://doi.org/10.2752/144871314X14159818597513

Bookchin, M. (2007). Social Ecology and Communalism. AK Press.

Braidotti, R. (2006). Posthuman, All Too Human: Towards a New Process Ontology. Theory, Culture & Society, 23(7–8), 197–208. https://doi.org/10.1177/0263276406069232

Braithwaite, J. (2002). Setting Standards for Restorative Justice. The British Journal of Criminology, 42(3), 563–577. https://doi.org/10.1093/bjc/42.3.563

Britannica, T. E. of E. (2019). Dichotomy | logic. Encyclopedia Britannica. https://www.britannica.com/science/dichotomy

Brundtland, G. H. (1987). Report of the World Commission on Environment and Development: Our Common Future (A/42/427; United Nations General Assembly Document). https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Butler, J. (2001). Giving an Account of Oneself. Diacritics, 31(4), 22–40.

Ceschin, F., & Gaziulusoy, Ý. (2019). Design for Sustainability: A Multi-level Framework from Products to Socio-technical Systems (1st ed.). Routledge. https://doi.org/10.4324/9780429456510

Chan, K. M., Gould, R. K., & Pascual, U. (2018). Editorial overview: Relational values: what are they, and what's the fuss about? Current Opinion in Environmental Sustainability, 35, A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003

Colebrook, C. (2019). A CUT IN RELATIONALITY. Angelaki, 24(3), 175–195. https://doi.org/10.1080/0969725x.2019.1620469

Collins, H. (2010). Creative Research: The Theory and Practice of Research for the Creative Industries (0 edition). AVA Publishing. https://www.perlego.com/book/546452/creative-research-pdf

Culbertson, C. (2013). The ethics of relationality: Judith Butler and social critique. Continental Philosophy Review, 46(3), 449–463. https://doi.org/10.1007/s11007-013-9271-z

Cullen, C. M., Aneja, K. K., Beyhan, S., Cho, C. E., Woloszynek, S., Convertino, M., McCoy, S. J., Zhang, Y., Anderson, M. Z., Alvarez-Ponce, D., Smirnova, E., Karstens, L., Dorrestein, P. C., Li, H., Sen Gupta, A., Cheung, K., Powers, J. G.,

Zhao, Z., & Rosen, G. L. (2020). Emerging Priorities for Microbiome Research. Frontiers in Microbiology, 11. https://doi.org/10.3389/fmicb.2020.00136

Dale, J. W. (2012). Understanding Microbes: An Introduction to a Small World. John Wiley & Sons. https://www.perlego.com/book/1004135/understanding-microbes-an-introduction-to-a-small-world-pdf

de la Bellacasa, M. P. (2017). Alterbiopolitics. In Matters of Care (pp. 125–168). University of Minnesota Press. https://www.jstor.org/stable/10.5749/j.ctt1mmfspt.7

Dimidi, E., Cox, S. R., Rossi, M., & Whelan, K. (2019). Fermented Foods: Definitions and Characteristics, Impact on the Gut Microbiota and Effects on Gastrointestinal Health and Disease. Nutrients, 11(8). https://doi.org/10.3390/nu11081806

Doelle, H. W. (1975). Fermentation. In H. W. Doelle (Ed.), Bacterial Metabolism (Second Edition) (pp. 559–692). Academic Press. https://doi.org/10.1016/B978-0-12-219352-1.50013-X

Dolejšová, M., & Kera, D. (2016). Fermentation GutHub: Designing for Food Sustainability in Singapore. Proceedings of the 2nd International Conference in HCI and UX Indonesia 2016, 69–76. https://doi.org/10.1145/2898459.2898470

Doordan, D. (2013). Developing Theories for Sustainable Design. In S. Walker & J. Giard, The Handbook of Design for Sustainability (pp. 57–72). Bloomsbury.

Douglas, A. E. (2018). Fundamentals of microbiome science: How microbes shape animal biology. https://www.perlego.com/book/740163/fundamentals-of-microbiome-science-how-microbes-shape-animal-biology-pdf

Drichel, S. (2019). RELATIONALITY. Angelaki, 24(3), 1—2. https://doi.org/10.1080/0969725x.2019.1620445

Ehrenfeld, J. R. (2008). Sustainability by Design. In Sustainability by Design. Yale University Press.

Emirbayer, M. (1997). Manifesto for a Relational Sociology. American Journal of Sociology, 103(2), 281–317. https://doi.org/10.1086/231209

Escobar 2018 Designs for the Pluriverse.pdf. (n.d.).

Escobar, A. (2011). Sustainability: Design for the pluriverse. Development, 54(2), 137–140. https://doi.org/10.1057/dev.2011.28

Escobar, A. (2018). Designs for the Pluriverse. Duke University Press.

Feola, G. (2020). Capitalism in sustainability transitions research: Time for a critical turn? Environmental Innovation and Societal Transitions, 35, 241–250. https://doi.org/10.1016/j.eist.2019.02.005

Forlano, L. (2017). Posthumanism and Design. She Ji: The Journal of Design, Economics, and Innovation, 3(1), 16–29. https://doi.org/10.1016/j.sheji.2017.08.001

Fournier, L. (2020). Fermenting Feminism as Methodology and Metaphor: Approaching Transnational Feminist Practices through Microbial Transformation. Environmental Humanities, 12(1), 88–112. https://doi.org/10.1215/22011919-8142220

Frascara, J. (2003). The dematerialization of design. In E. Resnick, The Social Design Reader. Bloomsbury Visual Arts. https://ereader.perlego.com/1/book/967830/32

Fry, T. (2010). Design as Politics. Berg Publishers.

Fry, T., & Tlostanova, M. (2020). A New Political Imagination: Making the Case (1st edition). Routledge.

Gaggìa, F., Baffoni, L., Galiano, M., Nielsen, D. S., Jakobsen, R. R., Castro-Mejía, J. L., Bosi, S., Truzzi, F., Musumeci, F., Dinelli, G., & Di Gioia, D. (2019). Kombucha Beverage from Green, Black and Rooibos Teas: A Comparative Study Looking at Microbiology, Chemistry and Antioxidant Activity. Nutrients, 11(1), 1. https://doi.org/10.3390/nu11010001

Gaver, W. (2016). Indiscipline. In Design as Research (pp. 193–196). Birkhäuser. https://www.perlego.com/book/651905/design-as-research-pdf

Gibson-Graham, J. K. (2008). Diverse economies: Performative practices for `other worlds'. Progress in Human Geography, 32(5), 613–632. https://doi.org/10.1177/0309132508090821

Grumezescu, A. M., & Holban, A. M. (2018). Diet, Microbiome and Health. Academic Press. https://ereader.perlego.com/1/book/1831081/7

Guattari, F. (2000). The Three Ecologies (I. Pindar & P. Sutton, Trans.). The Athlone Press.

Halse, J., & Boffi, L. (2014). Design interventions as a form of inquiry. 15.

Haraway, D. (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. Feminist Studies, 14(3), 575. https://doi.org/10.2307/3178066

Haraway, D. (2016). Tentacular Thinking: Anthropocene, Capitalocene, Chthulucene. In Staying with the Trouble: Making Kin in the Chthulucene (pp. 30–57). Duke University Press.

Hart, C. (1998). Doing a Literature Review: Releasing the Social Science Research Imagination. SAGE.

Harvey, D. (1996). Justice, Nature and the Geography of Difference (1st edition). Blackwell.

Held, M. (2016). Transdisciplinary Research through Design – Shifting Paradigms as an Opportunity. In Design as Research (pp. 186–192). Birkhäuser. https://www.degruyter.com/document/doi/10.1515/9783035607383-021/html

Hey, M. (2019a). Fermentation and the Possibility of Reimagining Relationality. Feminist Food Studies: Intersectional Perspectives.

Hey, M. (2019b). Fermenting Communications: Fermentation Praxis as Interspecies Communication. Public, 30(59), 149–157. https://doi.org/10.1386/public.30.59.149_1

Himes, A., & Muraca, B. (2018). Relational values: The key to pluralistic valuation of ecosystem services. Current Opinion in Environmental Sustainability, 35, 1–7. https://doi.org/10.1016/j.cosust.2018.09.005

Hirvilammi, T., & Helne, T. (2014). Changing Paradigms: A Sketch for Sustainable Wellbeing and Ecosocial Policy. Sustainability, 6(4), 2160—2175. https://doi.org/10.3390/su6042160

İstanbul Kültür Sanat Vakfi. (2021). 5th Istanbul Design Biennial closing event "Not quite a finissage!" https://youtu.be/2hMghnjsn30?t=285

Ives, C. D., Freeth, R., & Fischer, J. (2020). Inside-out sustainability: The neglect of inner worlds. Ambio, 49(1), 208–217. https://doi.org/10.1007/s13280-019-01187-w

Julier, G. (2013). From Design Culture to Design Activism. Design and Culture, 5(2), 215–236. https://doi.org/10.2752/175470813X13638640370814

Julier, G., & Kimbell, L. (2019). Keeping the System Going: Social Design and the Reproduction of Inequalities in Neoliberal Times. Design Issues, 35(4), 12–22. https://doi.org/10.1162/desi_a_00560

Kapp, J. M., & Sumner, W. (2019). Kombucha: A systematic review of the empirical evidence of human health benefit. Annals of Epidemiology, 30, 66–70. https://doi.org/10.1016/j.annepidem.2018.11.001

Kara, H. (2015). Creative research methods in the social sciences: A Practical Guide (1st edition). Policy Press. https://www.perlego.com/book/1657244/creative-research-methods-in-the-social-sciences-a-practical-guide-pdf

Kårlund, A., Gómez-Gallego, C., Korhonen, J., Palo-oja, O.-M., El-Nezami, H., & Kolehmainen, M. (2020). Harnessing Microbes for Sustainable Development: Food Fermentation as a Tool for Improving the Nutritional Quality of Alternative Protein Sources. Nutrients, 12(4). https://doi.org/10.3390/nu12041020

Katz, S. E. (2012). The Art of Fermentation: An In-depth Exploration of Essential Concepts and Processes from Around the World. Chelsea Green Publishing.

Kennedy, E. H., Cohen, M. J., & Krogman, N. T. (2015). Social practice theories and research on sustainable consumption. Putting Sustainability into Practice. https://www.elgaronline.com/view/edcoll/9781784710590/9781784710590.00009.xml

Kohtala, C. (2015). Addressing sustainability in research on distributed production: An integrated literature review. Journal of Cleaner Production, 106, 654–668. https://doi.org/10.1016/j.jclepro.2014.09.039

Kossoff 2015 Holism and the reconstitution of everyday life.pdf. (n.d.).

Kossoff, G. (2015). Holism and the reconstitution of everyday life: A framework for transition to a sustainable society. Design Philosophy Papers, 13, 25–38. https://doi.org/10.1080/14487136.2015.1085698

Kuznetsov, S., Santana, C. J., & Long, E. (2016). Everyday Food Science as a Design Space for

Community Literacy and Habitual Sustainable Practice. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, 1786–1797. https://doi.org/10.1145/2858036.2858363

Landecker, H. (2016). Antibiotic Resistance and the Biology of History. Body & Society, 22(4), 19–52. https://doi.org/10.1177/1357034x14561341

Lange, E. A. (2018). Transforming Transformative Education through Ontologies of Relationality. Journal of Transformative Education, 16(4), 280–301. https://doi.org/10.1177/1541344618786452

Leavy, P. (2017). Research Design: Quantitative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches. Guilford Publications. http://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=4832778

Lehtonen, A., Salonen, A., Cantell, H., & Riuttanen, L. (2018). A pedagogy of interconnectedness for encountering climate change as a wicked sustainability problem. Journal of Cleaner Production, 199, 860—867. https://doi.org/10.1016/j.jclepro.2018.07.186

Lejano, R. P. (2019). Relationality and Social–Ecological Systems: Going Beyond or Behind Sustainability and Resilience. Sustainability, 11(10), 2760. https://doi.org/10.3390/su11102760

Madigan, M. T., Bender, K. S., & Buckley, D. H. (2017). Brock Biology of Microorganisms (015 Edition). Pearson. https://www.perlego.com/book/811406/brock-biology-of-microorganisms-global-edition-pdf?queryID=ae3b37fc7017b892f002319d495497ea&searchIndexType=books

Mancilla García, M., Hertz, T., Schlüter, M., Preiser, R., & Woermann, M. (2020). Adopting process-relational perspectives to tackle the challenges of social-ecological systems research. Ecology and Society, 25(1). https://doi.org/10.5751/ES-11425-250129

Mandalaki, E., & Fotaki, M. (2020). The Bodies of the Commons: Towards a Relational Embodied Ethics of the Commons. Journal of Business Ethics, 166(4), 745–760. https://doi.org/10.1007/s10551-020-04581-7

Manzini, E., Coad, R., Friedman, K., & Stolterman, E. (2015). Design, When Everybody Designs: An Introduction to Design for Social Innovation. MIT Press. http://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=3339947

Manzini, E., Dilnot, C., & Staszowski, E. (2019). Politics of the Everyday. Bloomsbury Visual Arts.

Markham, A. (2013). Remix Cultures, Remix Methods: Reframing Qualitative Inquiry for Social Media Contexts. (2013). In N. K. Denzin, M. D. Giardina, K. Bhattacharya, C. B. Dillard, L. L. Ellingson, D. N. G. Fielding, & A. Markham, Global Dimensions of Qualitative Inquiry. Taylor & Francis Group. http://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=1181229

Markham, A. (2017, January 4). Bricolage: A keyword in remix studies - Annette Markham | social media, methods, and ethics. Annette Markham. https://annettemarkham.com/2017/01/bricolage-a-keyword-in-remix-studies/

Mazé, R., Olausson, L., Plöjel, M., Redström, J., & Zetterlund, C. (2013). Share this book: Critical perspectives and dialogues about design and sustainability. Axl Books. http://urn.kb.se/resolve?urn=urn:nbn:se:umu:diva-80120

Meadows, D. (1999). Leverage Points: Places to Intervene in a System. The Academy for Systems Change. http://donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system/

Mony, C., Vandenkoornhuyse, P., Bohannan, B. J. M., Peay, K., & Leibold, M. A. (2020). A Landscape of Opportunities for Microbial Ecology Research. Frontiers in Microbiology, 11. https://doi.org/10.3389/fmicb.2020.561427

Muratovski, G. (2015). Research for Designers: A Guide to Methods and Practice. SAGE. https://www.perlego.com/book/1431527/research-for-designers-a-guide-to-methods-and-practice-pdf

Pedersen, M. A. (2014). The fetish of connectivity. In Objects and Materials: A Routledge Companion (pp. 215–225). Routledge. https://doi.org/10.4324/9780203093610-26

Phelps, R., Fisher, K., & Ellis, A. H. (2007). Organizing and Managing Your Research: A Practical Guide for Postgraduates : A Practical Guide for Postgraduates. SAGE Publications. http://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=354865

Prescott, S. L., Wegienka, G., Logan, A. C., & Katz, D. L. (2018). Dysbiotic drift and biopsychosocial medicine: How the microbiome links personal, public and planetary health. BioPsychoSocial Medicine, 12(1), 7. https://doi.org/10.1186/s13030-018-0126-z

Raymond, P. C., Kaaronen, R. O., Giusti, M., Linder, N., & Barthel, S. (2021). Engaging with the pragmatics of relational thinking, leverage points and transformations – Reply to West et al. https://helda.helsinki.fi/handle/10138/325644

Redzepi, R., & Zilber, D. (2018). Chapter 3: Kombucha. In The Noma Guide to Fermentation: Including koji, kombuchas, shoyus, misos, vinegars, garums, lacto-ferments, and black fruits and vegetables. Artisan Books.

Rupprecht, C. D. D., Vervoort, J., Berthelsen, C., Mangnus, A., Osborne, N., Thompson, K., Urushima, A. Y. F., Kóvskaya, M., Spiegelberg, M., Cristiano, S., Springett, J., Marschütz, B., Flies, E. J., McGreevy, S. R., Droz, L., Breed, M. F., Gan, J., Shinkai, R., & Kawai, A. (2020). Multispecies sustainability. Global Sustainability, 3. https://doi.org/10.1017/sus.2020.28

Saldana, J., Leavy, P., & Beretvas, N. (2011). Fundamentals of Qualitative Research. Oxford University Press, Incorporated. http://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=665394

Sanzo, K. (2018, April 25). New Materialism(s). Critical Posthumanism Network. https://criticalposthumanism.net/new-materialisms/

Schlosberg, D. (2020). Sustainable materialism and environmental justice. In Environmental Justice (pp. 303–315). Routledge. https://doi.org/10.4324/9780429029585-27

Spackman, C. C. W. (2018). Formulating citizenship: The microbiopolitics of the malfunctioning functional beverage. BioSocieties, 13(1), 41–63. https://doi.org/10.1057/s41292-017-0051-6

Speed, C. (2006). Anthropocentrism and sustainable development: Oxymoron or symbiosis? 93, 323–332. https://doi.org/10.2495/SC060311

Stålhammar, S., & Thorén, H. (2019). Three perspectives on relational values of nature. Sustainability Science, 14(5), 1201–1212. https://doi.org/10.1007/s11625-019-00718-4

The Kilpisjärvi Collective. (2021). Introducing With Microbes: From witnessing to withnessing. SocArXiv. https://doi.org/10.31235/osf.io/62t34

Tsing, A. L. (2015). The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins (Edition Unstated). Princeton University Press.

Walsh, Z., Böhme, J., & Wamsler, C. (2020). Towards a relational paradigm in sustainability research, practice, and education. Ambio. https://doi.org/10.1007/s13280-020-01322-y

West, S., Haider, L. J., Masterson, V., Enqvist, J. P., Svedin, U., & Tengö, M. (2018). Stewardship, care and relational values. Current Opinion in Environmental Sustainability, 35, 30–38. https://doi.org/10.1016/j.cosust.2018.10.008

West, S., Haider, L. J., Stålhammar, S., & Woroniecki, S. (2020). A relational turn for sustainability science? Relational thinking, leverage points and transformations. Ecosystems and People, 16(1), 304–325. https://doi.org/10.1080/26395916.2020.1814417

West, S., Haider, L. J., Stålhammar, S., & Woroniecki, S. (2021). Putting relational thinking to work in sustainability science – reply to Raymond et al. Ecosystems and People, 17(1), 108–113. https://doi.org/10.1080/26395916.2021.1898477

White, D. F., Rudy, A. P., & Gareau, B. J. (2016). Environments, natures and social theory: Towards a critical hybridity. Palgrave Macmillan.

Willis, L. D., & Chandler, C. (2019). Quick fix for care, productivity, hygiene and inequality: Reframing the entrenched problem of antibiotic overuse. BMJ Global Health, 4(4), e001590. https://doi.org/10.1136/bmjgh-2019-001590

Wilson, G. T., & Bhamra, T. (2020). Design for Sustainability: The Need for a New Agenda. Sustainability, 12(9), 3615. https://doi.org/10.3390/su12093615

Blank page

Appendices

Appendix A: Literature searches for Relationality

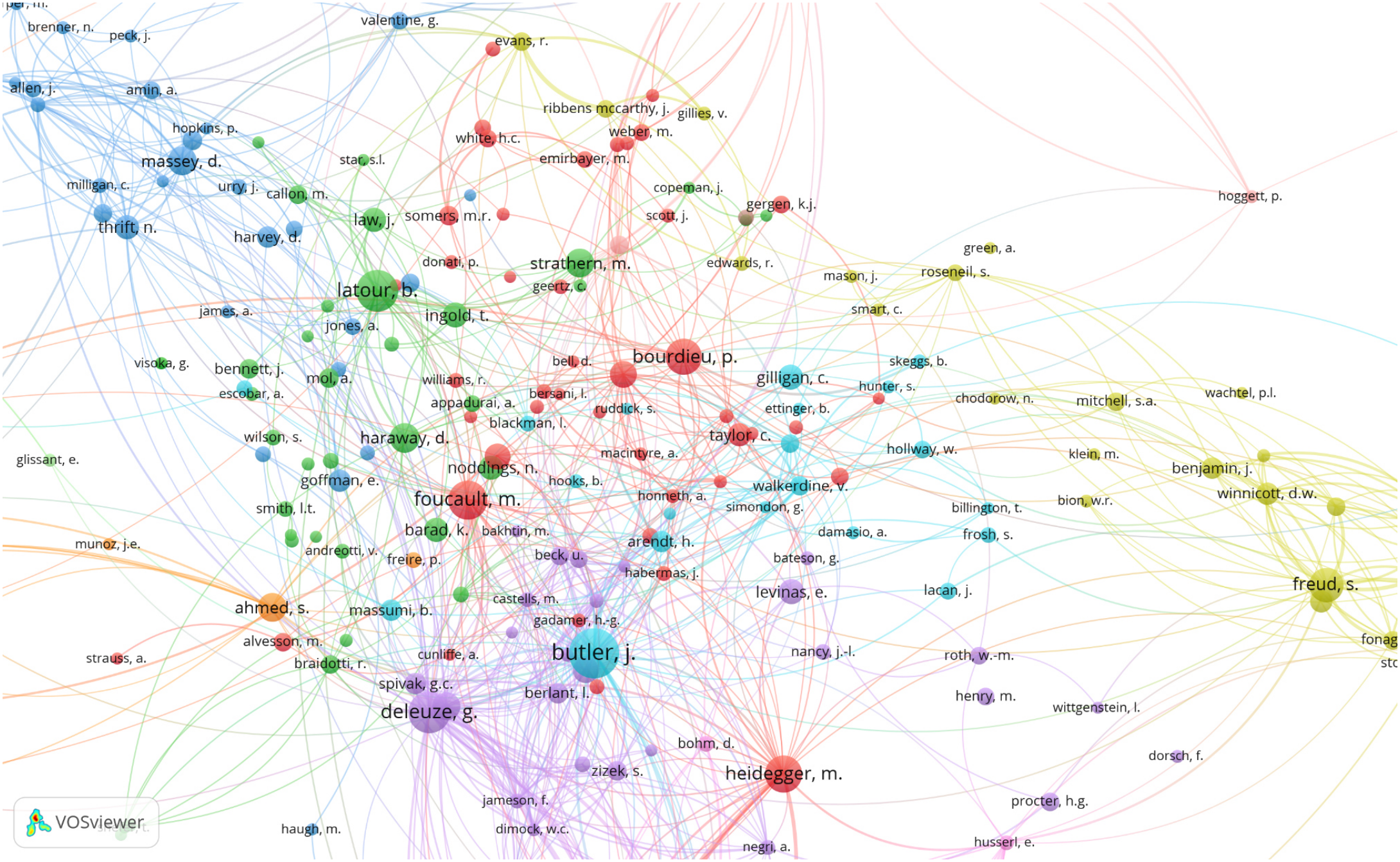
Syntax	Database	Search type	Search Filters	Hits	Notes	Items listed ...	Items selected...
relationality	dimensions.ai	Title & abstract	Articles as publication type	2548	The created bibliographical map gives insights into disciplines		
relationality	microsoft academic			1184	Insights on Top Topics and Top Journals		
interconnectedness	microsoft academic	This is a title in MA		6511	Insights about topics which are related to relationality		
relationality AND interconnectedness	dimensions.ai	Title & abstract		30			
collective imagination relationality	microsoft academic			139			
relatonality	google scholar			63000	First 100 results were reviewed	23	18
imagining relationality	microsoft academic			50000	Results are not relevant		
sustainability and relationality	microsoft academic		Sustainability as Top Topic	50000	Pedagogical studies are dominant. The intersection of relationality and sustainability is limited.	10	9
relationality	dimensions.ai	Title & abstract	fields: 05 Environmental Sciences 04 Earth Sciences	63	Low number of results: relationality is underrepresented in environmental sciences. All results are reviewed	28	15
relationality	dimensions.ai	Title & abstract	FCR sorting	3178	First 50 result were reviewed	23	16
relationality	scopus	Title	language: en	528	All results were reviewed	111	57
ecological relationality	google scholar			50000	The first 100 results were reviewed. The keyword 'ecological' resulted in more results about relationality compared to "sustainability"	25	14
						SUM 129	

Appendix B: Literature searches for Kombucha Fermentation

Syntax	Database	Search type	Search Filters	Hits	Notes	Items listed ...	Items selected...
kombucha AND fermentation	dimensions.ai	Title & abstract	year: 2018-2021	260	Recent studies were explored. The search provided microbiology related sources.	7	7
microorganism AND sustainability	scopus	Title & abstract		2239	The framing of microbiology in the sustainability science is extractive and utilization based.	4	2
microorganism AND ecology	scopus	Title & abstract		17263			
(microorganism OR microbe) AND ecology AND review	dimensions.ai	Title & abstract		1053		6	2
kombucha AND fermentation	dimensions.ai	Title & abstract	field: 16 Studies in Human Society	21	Searching kombucha fermentation in cultural studies.	11	10
				SUM 21			

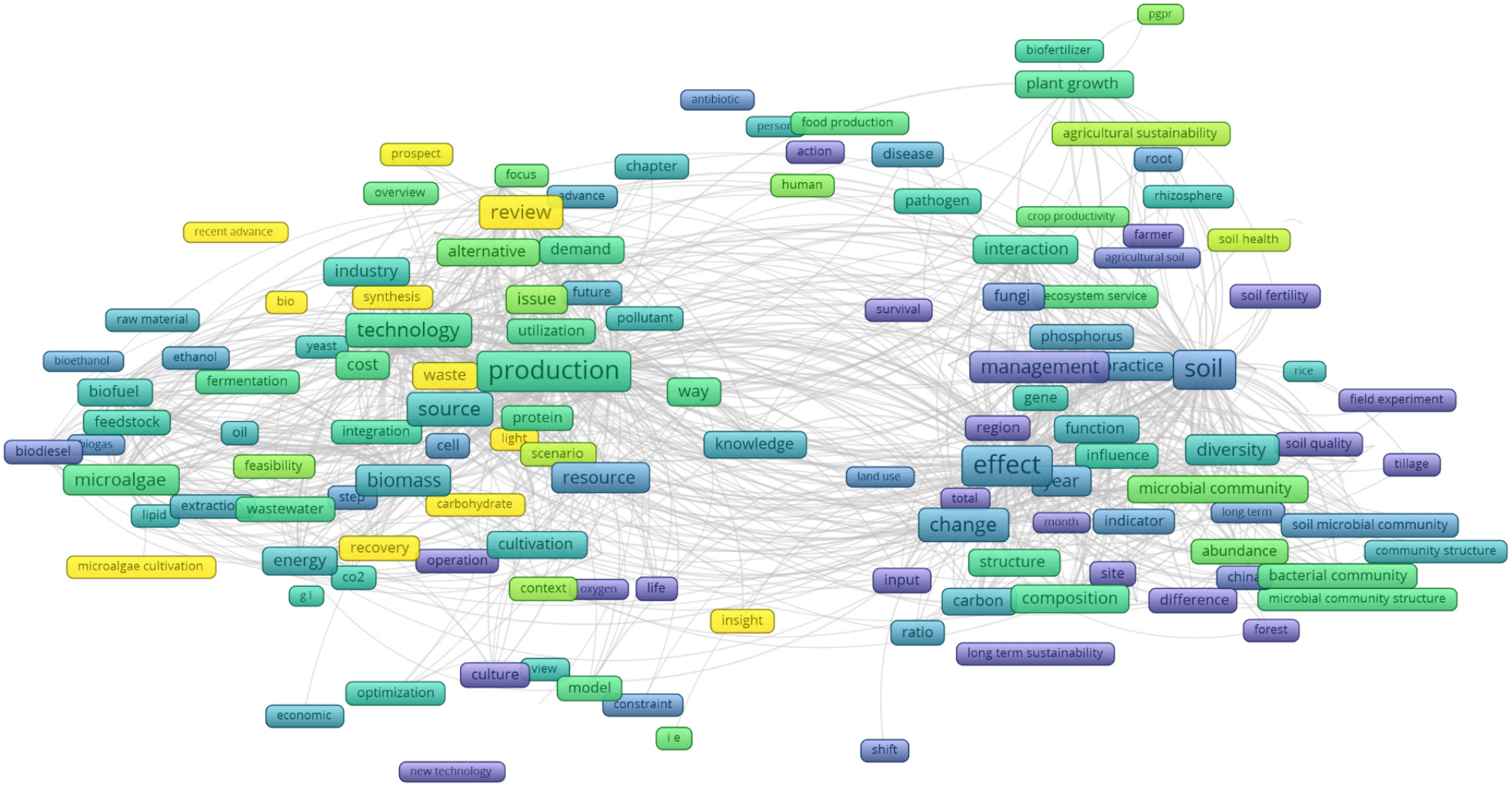
Appendix C: Influencer authors of the concept of relationality

Network Visualization based on co-citation data of cited authors. The visualization data is produced from search results on "relationality" from Scopus. Zoomed: Network Visualization: Citation | Cocitation based on Cited authors

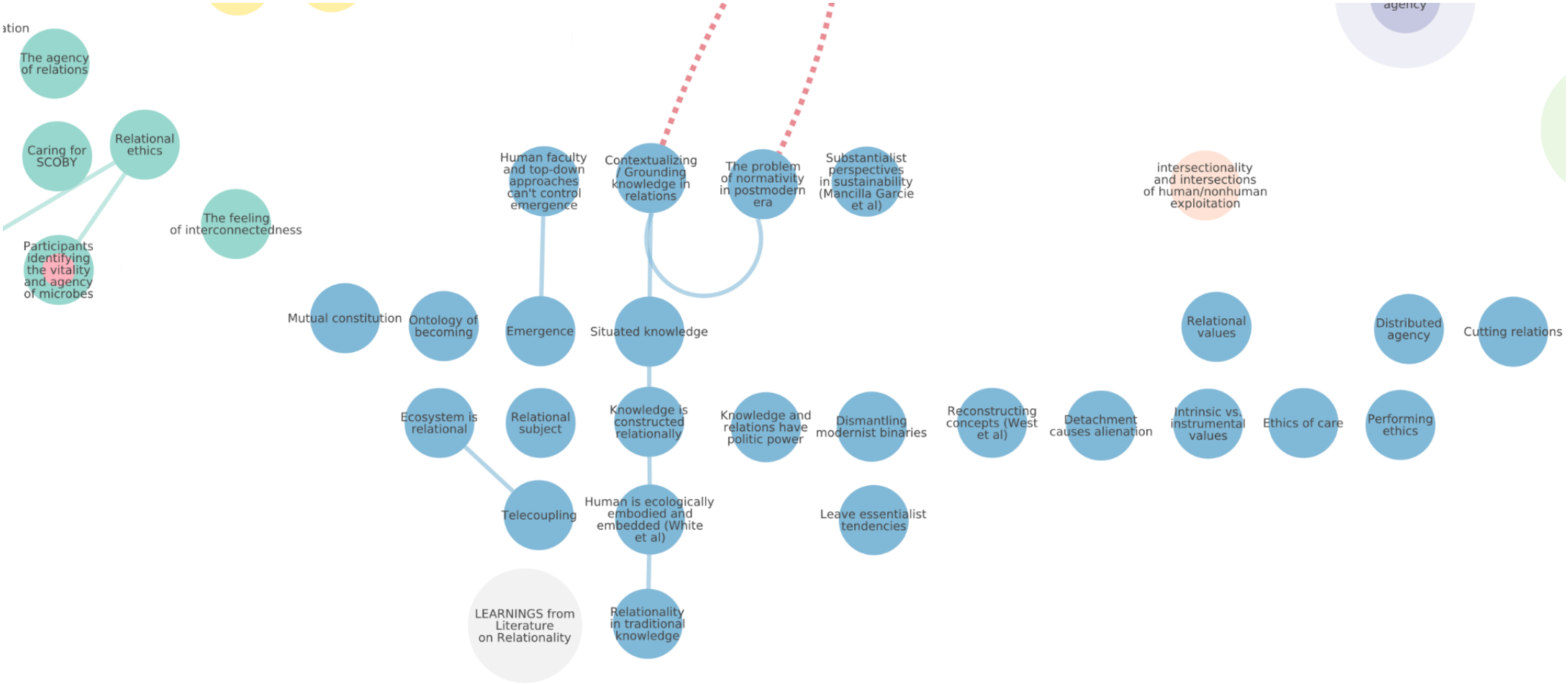


Appendix D: Keyword extraction map regarding microorganisms in sustainability research

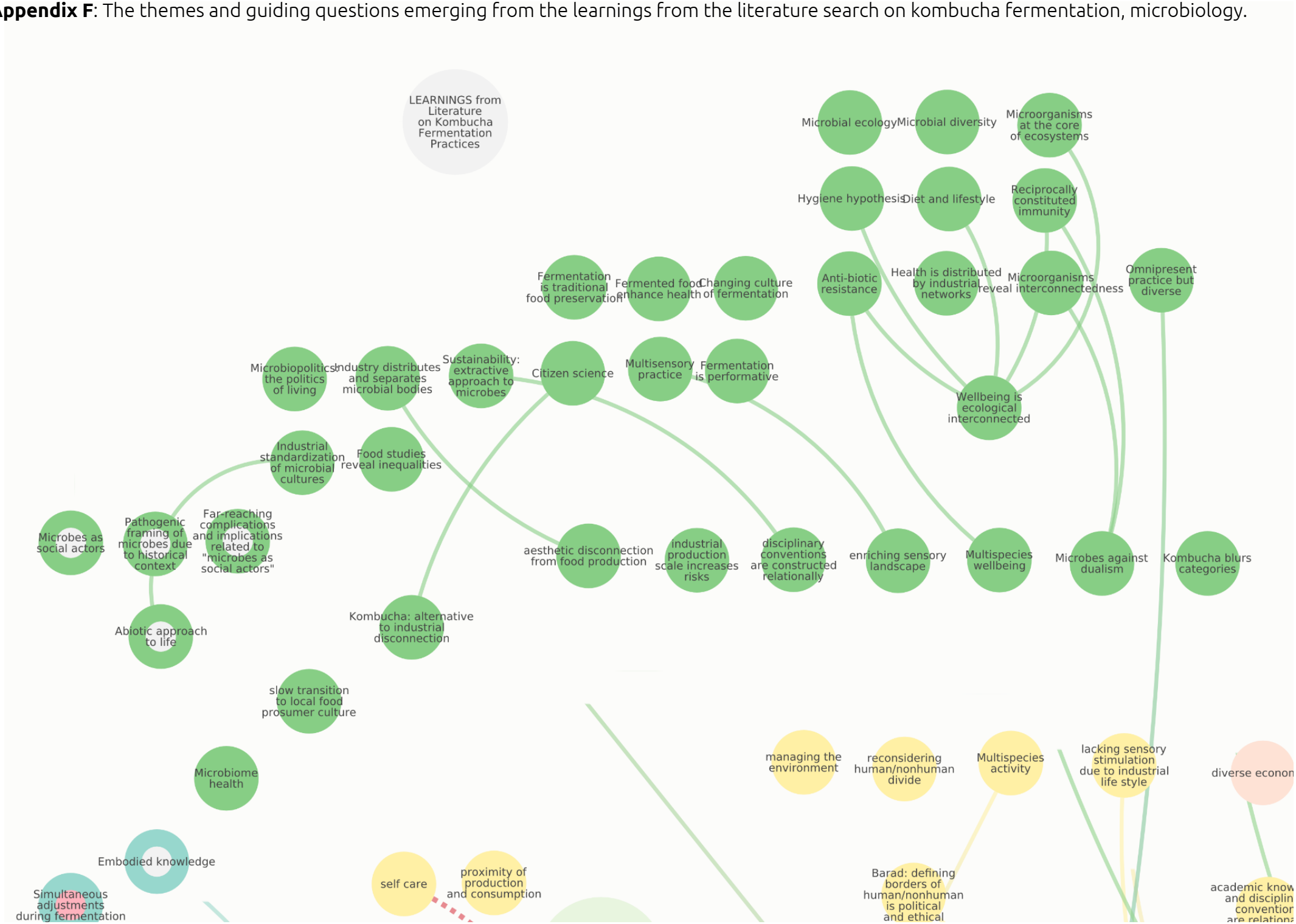
Term occurrence map based on text data of titles and abstracts of documents. Scopus search string: "microorganism AND sustainability"



Appendix E: The themes and guiding questions emerging from the learnings from the literature search on relationality



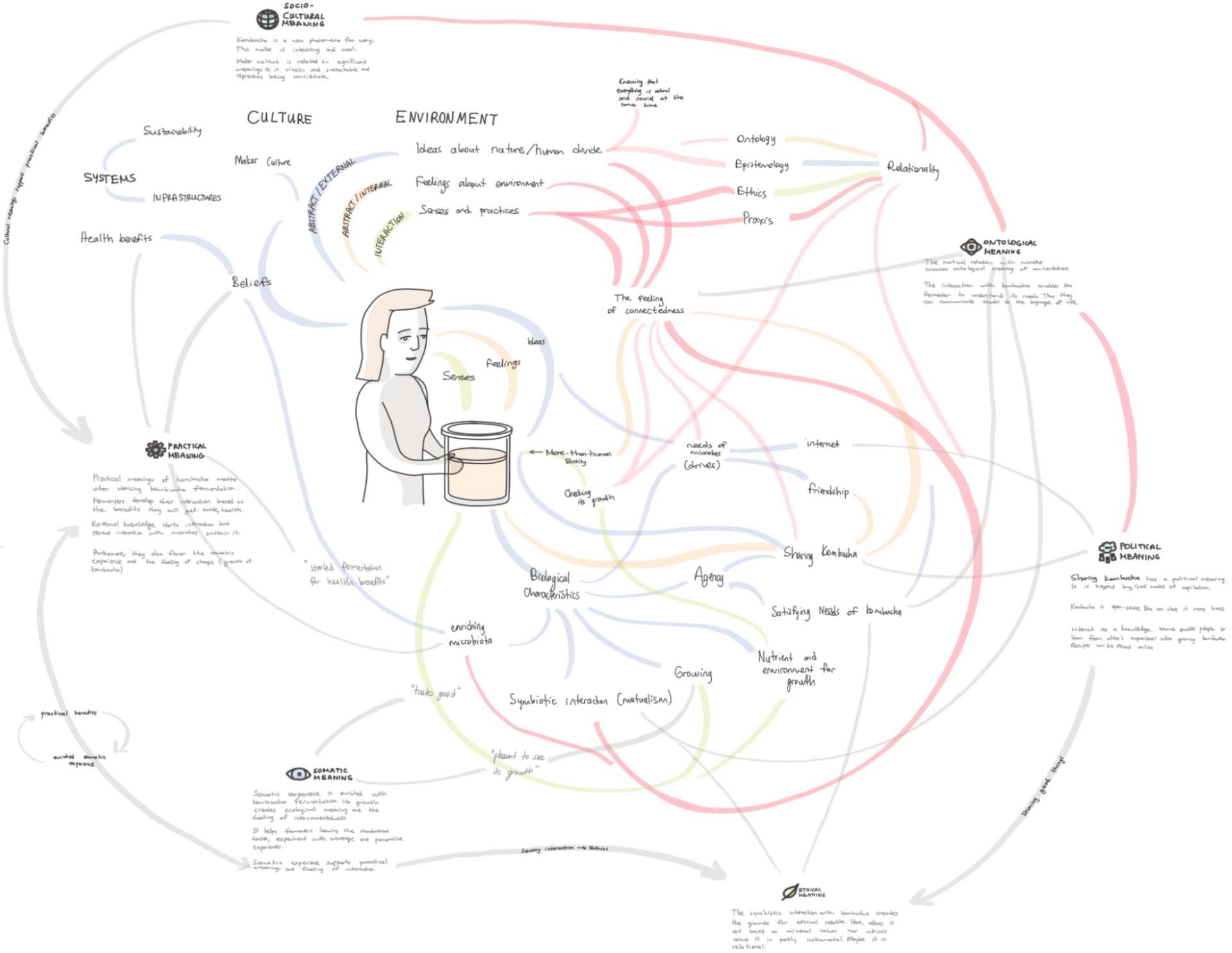
Appendix F: The themes and guiding questions emerging from the learnings from the literature search on kombucha fermentation, microbiology.



Appendix G: Mindmap for preparing interview questions

The mindmap integrating learnings from the literature search, learning diaries, and personal experiences.

The learnings are connected to the varying themes of human-microbial relation during kombucha fermentation processes



Appendix H: Interview questions for kombucha brewers

Add cover

Questions for kombucha brewers

1 backlink

Major Questions | Follow up question | Alternative duplicate questions | Insignificant questions

Personal History

- How did you start fermentation?
- What kind of benefits does kombucha have?
- Why? | What expectations did you have?
- What is your motivation for fermenting kombucha?

Practical Level

- In which ways kombucha satisfies your needs?
- Why do you value the experience of fermenting kombucha?

Somatic Interaction

- Which senses does the kombucha appeal to?
- Do you think fermentation practices enrich sensory stimulation or diversity of tastes people experience?
- Do you like trying new tastes and did you try different recipes with kombucha?
- What are the differences between kombucha and industrially produced beverages?
- Do you follow the growth of kombucha when fermenting?
- How do you make sure that kombucha is healthy when growing?

Eco-psychological Meanings

- In which ways kombucha is making you feel good?

Eco-psychological Meanings

- In which ways kombucha is making you feel good?
- What do you feel about caring for a living thing?
- Do you consider kombucha as a natural entity?
- Do you think kombucha is a part of nature?
- How do you define your interaction with nature?
- Can you relate fermenting kombucha to environmental sustainability?
- Do you think it as a sustainable act?
- In which ways kombucha is healing you (making you feel good) internally?

Political Meanings

- What was the level of your knowledge when you first fermented kombucha?
- How do you learn new knowledge about kombucha when needed?
- How did you learn how to ferment kombucha?
- Did you think whether fermenting kombucha makes your lifestyle more sustainable?
- What do you feel about sharing kombucha with other people?

Ethical Meanings

- How do you understand the needs of kombucha?
- How do you define your transaction (exchange) with kombucha? What kind of things you do for keeping kombucha living?
- What are your motivations and feelings for keeping the kombucha healthy and living?
- Why do you value the experience of fermenting kombucha? *(Intrinsic value vs. Instrumental value)*

Socio-Cultural Meanings

- What is your experience with traditional fermentation activities?
- In which ways kombucha is different from traditional fermentation activities?

Ontological Level

- What is the internal meanings of kombucha for you?
- What do you think about interacting with a living thing?
- Do you feel that you do enough for the environment?

Appendix I: Notes from recipes that participants prepared during collective kombucha fermentation activity.

Recipe notes

Participant	Notes	Category	Insight
P2	□Shebrewed orange flower tea]	Tools and ingredients	
P2	Neither the SCOBYnor the starter tea must be exposed to hot water.	Knowledge emotions thought Wellbeing of SCOBY	
P2	The rough and dark side of SCOBYmust be turned downward when placing SCOBY in a jar.	Knowledge emotions thought	
P2	Rinse the SCOBY before fermentation.	Knowledge emotions thought	The unnecessary step of cleaning reveals hygiene concerns
P2	Because the functional system of bacteria consumes carbohydrates, it is necessary to add anything that can substitute sugar. Due to the obvious harmful effects of sugar, sugar from apple juice may be used.	Knowledge emotions thought Wellbeing of SCOBY	Health concerns regarding sugar
P2	A thin coat of SCOBYbegan to appear.	Senses □□	
P2	The fermentation continues, and a scent starts to develop.	Senses □□	
P2	Since this is a new kombucha, the developing later is thin. I think the second or third ferment will develop a thicker layer.	Knowledge emotions thought Senses □□	The thickness of SCOBY layer is an important indicator. Moreover, past experiences guide the user to guess reasons of the situation
P2	The amount of sugar is a little high to me or it could be because of not using sugar generally.	Personalization Senses □ □	
P2	Survival of kombucha made me happy. I was careful in keeping it away from dust, air circulation and molded foods.	Knowledge emotions thought Wellbeing of SCOBY	
P1	I took my Kombucha from the cabinet. When I took it into my hand, it had a different color and texture. When I opened the scarf, I saw it was spoiled. I was sad when I found out 4□5SCOBYlayer got spoiled, but I had to dispose it.	Knowledge emotions thought Senses Wellbeing of SCOBY □	Sadness due to spoilage of SCOBY
P1	I took a SCOBY from □P4□again.Itold about kombucha to a friend. After that evet, he/she wanted to grow kombucha.	Knowledge emotions thought	Friends' proposal leading to the interest in kombucha fermentation
P1	Because I don't like sweet, I prefer to use less sugar. When it is sweet, I feel that it is less healthy.	Knowledge emotions thought Personalization Tools and ingredients □□	Relating sweetness to lack of health
P1	I boiled the water in a small pot used for Turkish coffee. For shortening the time...	Personalization Tools and ingredients	Small and quick fixes thanks to flexibility of practice
P1	The smell and scent of the new SCOBYis strange to me. When I first took it into my hand, I felt its scent. It was more acidic. Different than my previous SCOBYs. They were changing their color, shape and scent due to the ingredients the shape of the containers.	Senses □□□	Different starter teas lead to different colors and scents
P1	□Sheisusing paper towel instead of cloth, but she was unsure.]	Knowledge emotions thought Personalization	
P1	I am curious about how the-new-but-old kombucha will respond. I can't call it my kombucha yet. I can't really feel that it belongs to me.	Knowledge emotions thought Personalization	Participant needs a kind of attachment to feel the ownership of SCOBY

continues to next page

Participant	Notes	Category	Insight
P1	P4 talked about the idea of frying and eating [kombucha]. Initial I found it interesting, but later I could not help thinking that it was like taking its life	Knowledge emotions thought Wellbeing of SCOBY	Frying kombucha means killing it, and this is a disturbing idea
P1	I don't like mixing the sugar, so I pour it from a distance. When the sugar particles are not visible, I understand its solved in water	Personalization Senses	Small and quick fix
P1	I don't use metal spoon, though I am not sure whether it is harmful or not	Knowledge emotions thought	Kullanılan malzeme türü kaygısı
P1	I am brewing green tea and jasmine tea. I like my mother's tea mix. I am using a tea bag but unfortunately it is waste. I think an alternative for that.	Knowledge emotions thought Tools and ingredients	Using tea bag creates concerns of creating waste
P1	Once I mixed many kinds of herbs for the starting tea, but I did not like its taste.	Knowledge emotions thought Senses Tools and ingredients	Trying new recipes does not succeed each time.
P3	I used hibiscus tea to make the tea color nicer.	Senses Tools and ingredients	The need of making the color nicer
P3	Until now, I used the older SCOBY too. However, my own SCOBY had also got thicker. So I used both	Knowledge emotions thought Personalization	Participant identifies SCOBYs, and develops plans accordingly
P3	I put it somewhere without sunlight	Wellbeing of SCOBY	
P3	Half of the SCOBY was sticking out when I checked it. The SCOBY of □P4□was pushing from below. I heard that P1's SCOBY has spoiled. When I read what she □P1□wrote, I checked mine immediately. I was afraid it would get mold. I washed my hands. I took the old SCOBY which was under the other one. This was the first time I needed to intervene. I am afraid about spoiling it due to touching too.	Knowledge emotions thought Senses Wellbeing of SCOBY	Learning that other participant had spoiled her SCOBY, made her nervous about her own SCOBY. She intervened to fix its position but she was also careful when touching
P3	I was sticking out again but I did not want to touch it too much	Knowledge emotions thought Senses	Although she was concerned, she did not want to touch it
P3	There is a residual in the bottom and the layer is thicker.	Senses	
P3	When opening the cabinet door, I felt the scent. I think it is done	Knowledge emotions thought Senses	
P3	The SCOBY has really grown. There was an air bubble on the SCOBY. I popped it	Knowledge emotions thought Senses	
P3	I decided to finish it because there was a lot of sediment. I was really bubbly, and its color was good. However, the scent was not good right after fermentation	Knowledge emotions thought Senses	
P4	□She named the SCOBYs waiting in the fridge; old, small, big, young. She planned how to ferment them according to their previous fermentation teas, and which tea to use with them.]	Knowledge emotions thought Personalization Tools and ingredients Wellbeing of SCOBY	The knowledge of not mixing taste of different tea and using the same SCOBY for same kind of tea
P4	□She sterilized the jars with hot water].	Knowledge emotions thought Tools and ingredients Wellbeing of SCOBY	Concerns about hygiene to keep kombucha microbes healthy
P4	It should not be exposed to air and dust. It needs dry and dark environment.	Wellbeing of SCOBY	
P4	I learnt that stevia does not replace sugar for kombucha. I learnt that and I added water with sugar.	Knowledge emotions thought Personalization	Durability of bacterial community enables experimentation and fixing mistakes

continues to next page

Participant	Notes	Category	Insight
P4	I try to keep the mixing spoon clean.	Tools and ingredients Wellbeing of SCOBY	
P4	I washed my hands and I dipped my fingers to measure its temperature.	Senses	Using finger for measurement
P4	When the taste of sugar is recognizable, I understand that there is enough food for kombucha	Knowledge emotions thought Senses Wellbeingof SCOBY	Taste of sugar as an indicator connecting humans sense with microbe sense
P4	The older kombucha is growing slowly. I should have checked it before using stevia... Even though it is old, its survival is important. Don't leave it starving deliberately.	Wellbeing of SCOBY	Feeling responsible for the SCOBY
P4	Seeing its growth makes me happy. I think it is healthy	Knowledge emotions thought Senses	
P4	The old kombucha is growing slowly. I wish I checked it out before using stevia. However, I am also curious about the outcome.	Knowledge emotions thought Personalization	The knowledge about practice is getting better by trial and errors
P4	I am occasionally smelling the jars during fermentation	Senses	
P4	I put some fermented tea to the jar before putting them in fridge so they don't die	Knowledge emotions thought	Watching out the environment of microbes for ensuring wellbeing of kombucha
P4	To make its taste more acidic, I kept the kombucha teas in room temperature for a while. I extended the fermentation duration of old SCOBY.	Knowledge emotions thought Personalization Senses	Fermentation duration changes according to desired taste

Blank page

Appendix J: Workshop Board for Collective Kombucha Fermentation Activity

The recipe notes that participants wrote during brewing kombucha were compiled onto this board. The board is used during collective reflection workshop. "Kombucha Fermentation Steps" table was filled by the researcher. "Reflecting on the Kombucha Fermentation" board was filled with participants.

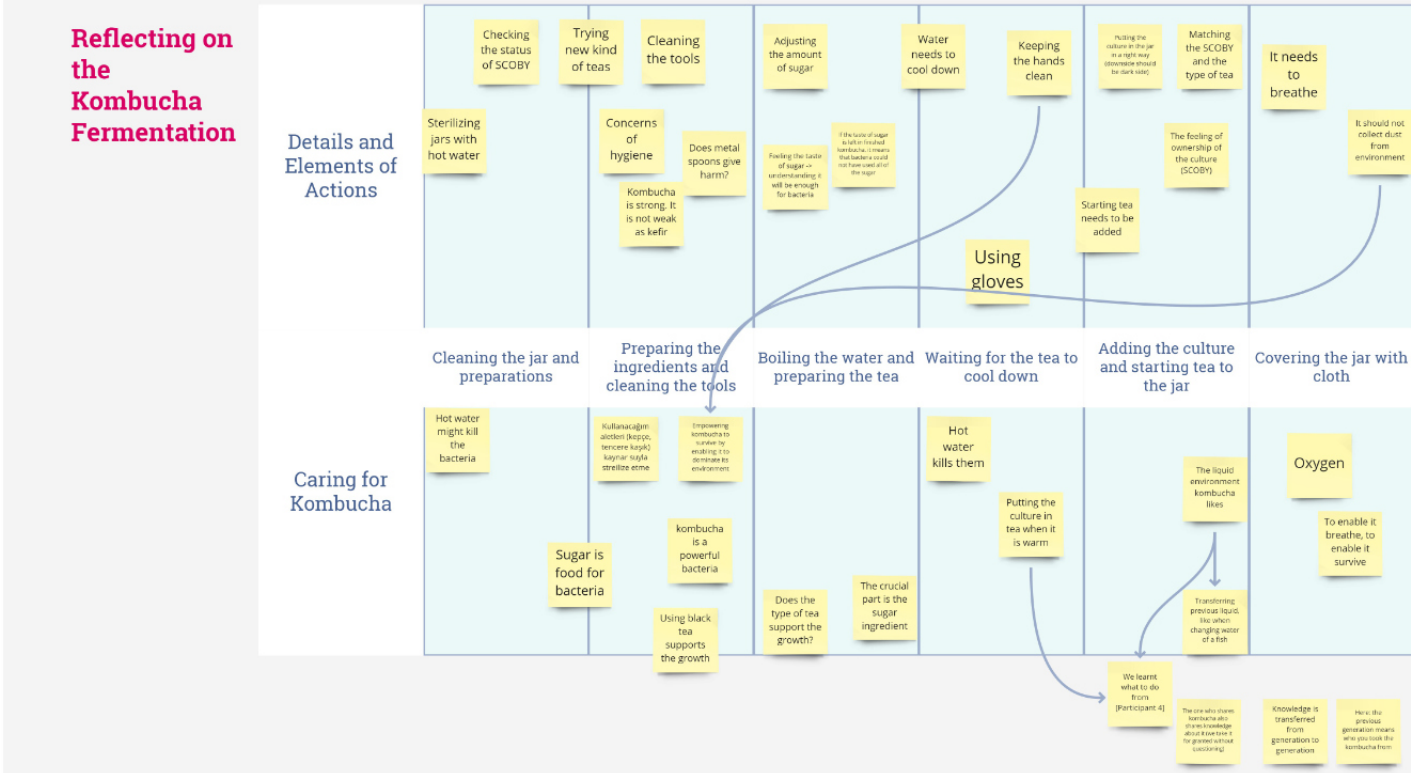
Kombucha Fermentation Steps

Symbols: Seeing, Smell, Taste, Touching, Information, Trial and Error

	Cleaning the jar and preparations	Preparing the ingredients and cleaning the tools	Boiling the water and preparing the tea	Waiting for the tea to cool down	Adding the culture and starting tea to the jar	Covering the jar with cloth
Participant 3		Green tea and hibiscus -> the color			I used the old scoby that I took from Participant 4. Yet my scoby grew too	
Participant 4	Named the scoby's waiting in fridge: older, younger, dry	Cleaning the jars. I also clean the spoon used for mixing	I learnt that stevia can't replace sugar. After learning, I added water with sugar	I washed my hands and put my finger in liquid to measure temperature		Feeling the sweetness -> it has enough food for bacteria
Participant 2		Orange blossom tea	Since bacteria consumes carbohydrates, it is mandatory to put something to replace sugar	Avoid putting the starter tea and the culture in hot water	The dark and rough side of the culture should be face down. Wash the culture with clean water before fermentation.	
Participant 1	Since my kombucha spoiled, I took a new one from [Participant 4]	Green tea and jasmine tea. I like my mother's mix. I am curious how old but new kombucha will respond.	Because I don't like sweet, I prefered to use less sugar when fermenting. Feeling the sweet taste makes me think that it less healthy		I can't call the old but new kombucha as "my" kombucha.	I covered it by using paper towel and hairband. I could not find cloth
The researcher	Paying attention to not leave soap residue on jars.	Green tea Coffee kombucha. I used my *eye's word** when putting ingredients in.	The dust particles in air disturbs me	I did not keep the tea leaves in water for a long time		

* Eye's word is a direct transition from a Turkish phrase. It means that measurement is made by the decision of the eye.

Reflecting on the Kombucha Fermentation



continues to next page

Putting the jar in a dark place	Waiting the fermentation	Checking the fermentation process	Finishing the fermentation	Filtering	Storing the culture for until next fermentation
I placed it somewhere without sunlight		After reading what [Participant 1] experienced (spoiled scoby), I immediately checked mine. I was afraid of moulds.	I felt the smell when I opened the closet. Its color is beautiful too		
It should not be exposed to dust and open air. Needs dry and dark environment	I smell the jars several times during fermentation	Seeing that it is getting thicker makes me happy. So I can understand it is health	I extended the fermentation duration of the old kombucha	I kept the kombucha in the room temperature for a longer time to make it taste more acidic	When storing, I also put the liquid from previous batch so they don't die
	A thin layer is forming	Fermentation is continuing. I began to feel the smell	Because it is a new kombucha, the new layer was thin. I think will have thicker layer in next fermentations		I paid attention for keeping it distant from dust and spoiled foods
	I had many bubbles	I drank some kombucha two days before ending fermentation			

Other thoughts and feelings

When I uncovered the cloth, I saw that 4-5 discs were not healthy. I was sad but I had not option other than disposing it

I took a scoby from [Participant 4] again. I had a friend with me and my friend also got curious about growing kombucha.

I brew it with less sugar because I don't like sweet. Drinking a sweet tea feels like it is unhealthy.

I wonder how the new but old scoby will respond. I can't call it "mine" yet. I don't exactly feel that it belongs me.

[Participant 4] mentioned that it can be eaten after frying. I was curious about its taste but I also thought that it would be killing it.

When I heard [Participant 1] had a spoiled scoby, I checked mine immediately. I was worried spoilage too. I washed my hands and repositioned the scoby. This was the first time I intervened the fermentation. I am also worried about touching it.

I named the scoby's stored in the fridge: old, young, dry. I matched the teas with scoby according to their condition and which tea I used in previous fermentation.

Although it is old, it should live. I should not leave it starving delibaretely.

I learnt that stevia is not a replacement for sugar in fermentation. Then I added water with sugar.

Old scoby grows slowly. I wish I had checked it before using stevia instead of sugar. Nevertheless, I am curious about the outcome.

A participant validates her knowledge by telling that she keeps the kombucha alive for years

Aybars Senyildiz

Recognizing Relationality through Kombucha Fermentation Practices

2021